# Evolution
## Model or fate for human long term development ?

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Vienna, 10 September 2014

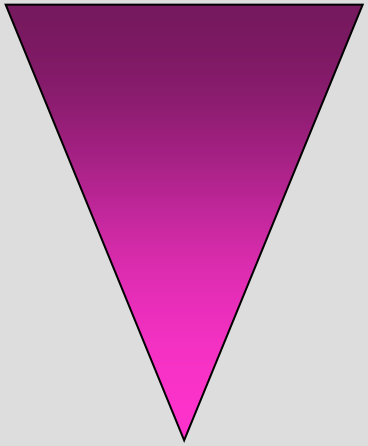
# Overview

- Basic principles of evolution
- Abiotic framework conditions
- Evolution of terrestrial ecosystems – the frameworks for human evolution
- Commons and peculiarities of human evolution

# Basic principles of evolution

# Evolution - interdependent processes between different hierarchies

**Energetic hierarchy**



**Planetary processes**

**Terrestrial abiotic processes**

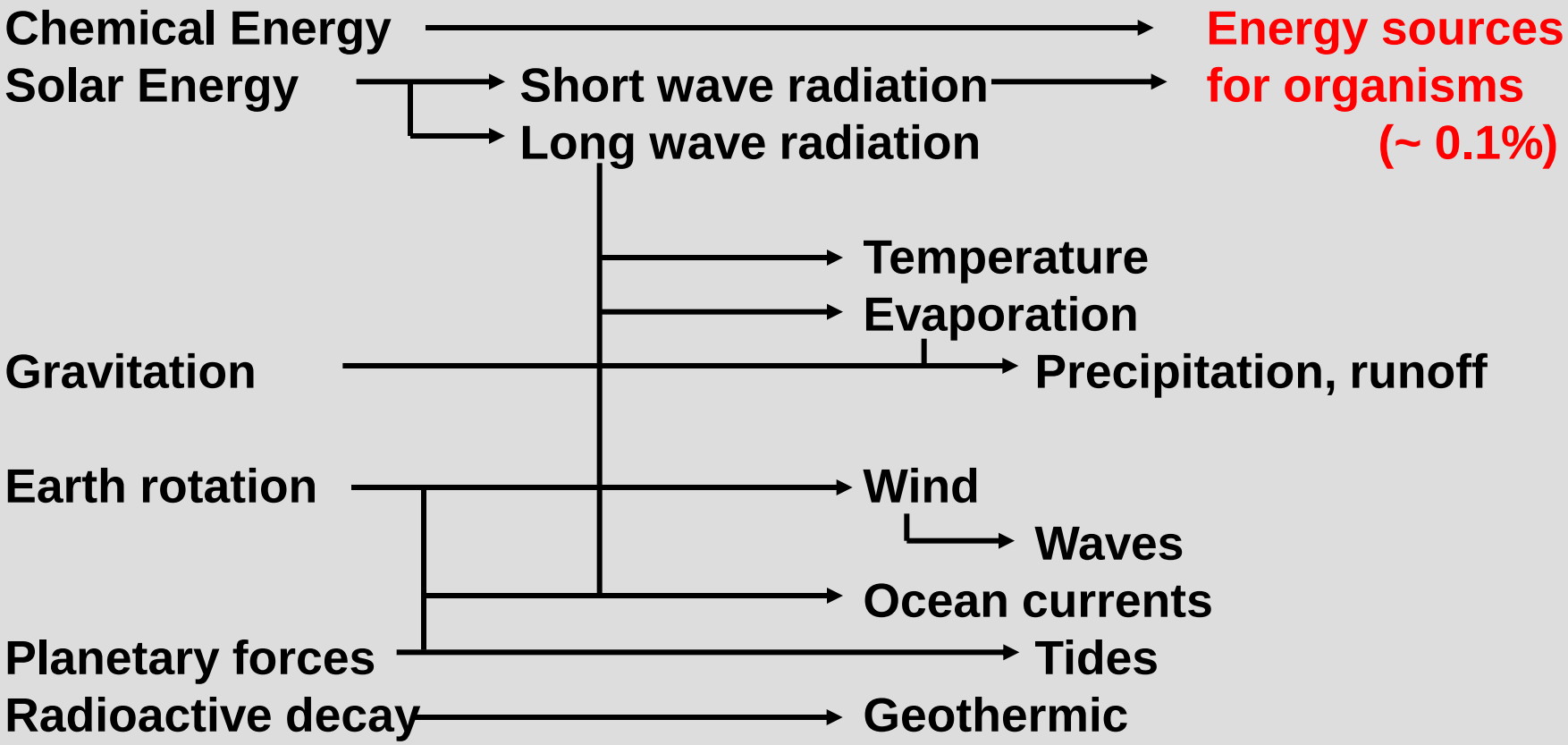
**Biotic processes**

**Hierarchy of Self - organisation**

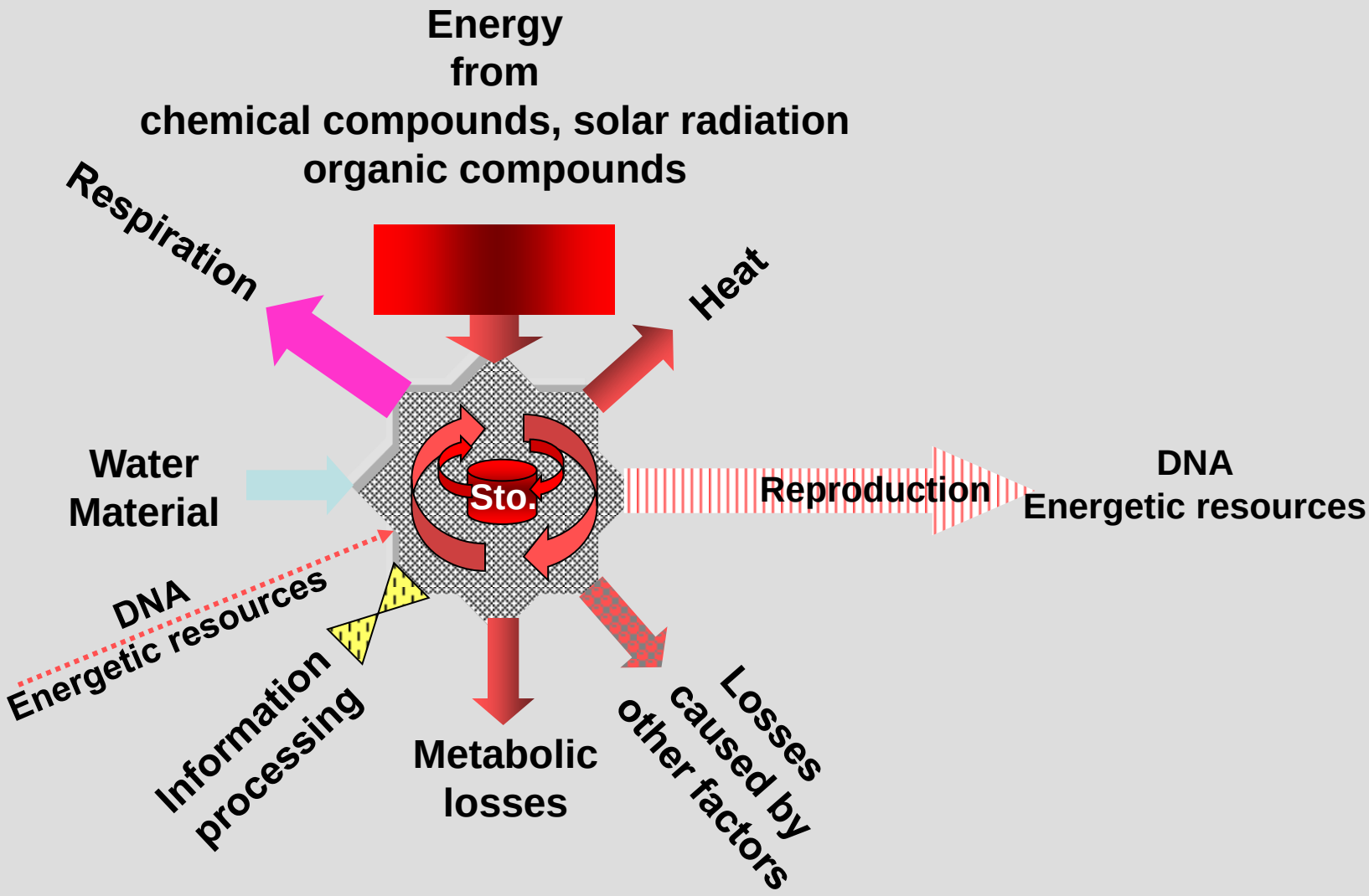
„Strong“

„Weak“

# Energy directly used by organisms within the continuous terrestrial energy regime



# Successful evolution depends on the continuous genetic reproduction **and** the balance of energy and material flows

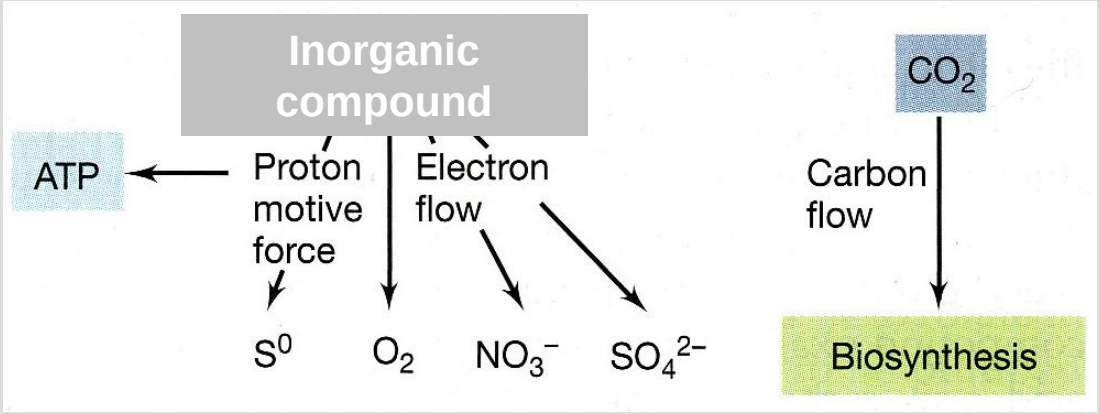


# Basic characteristics of all organisms

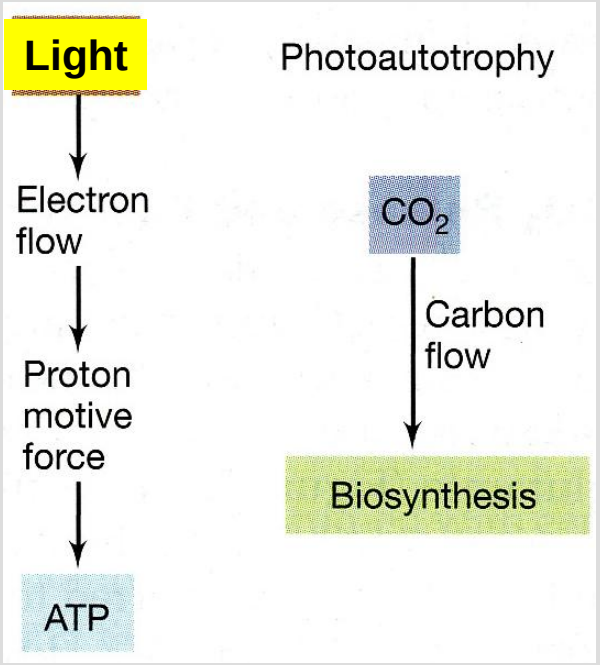
- Nonlinear dependence on physical and chemical environmental factors within narrow limits (optimum functions)
- Limited capacities for energy transformation
- Limited capacities for material transformation
- Limited capacities for information perception and processing (necessary to adapt to relevant local conditions at individual scale)
- Inherent tendency to overproduction to compensate unpredictable losses

# The two sources of primary energy

Chemoautotrophy




Photoautotrophy




Source: Madigan et al. 2003, modified

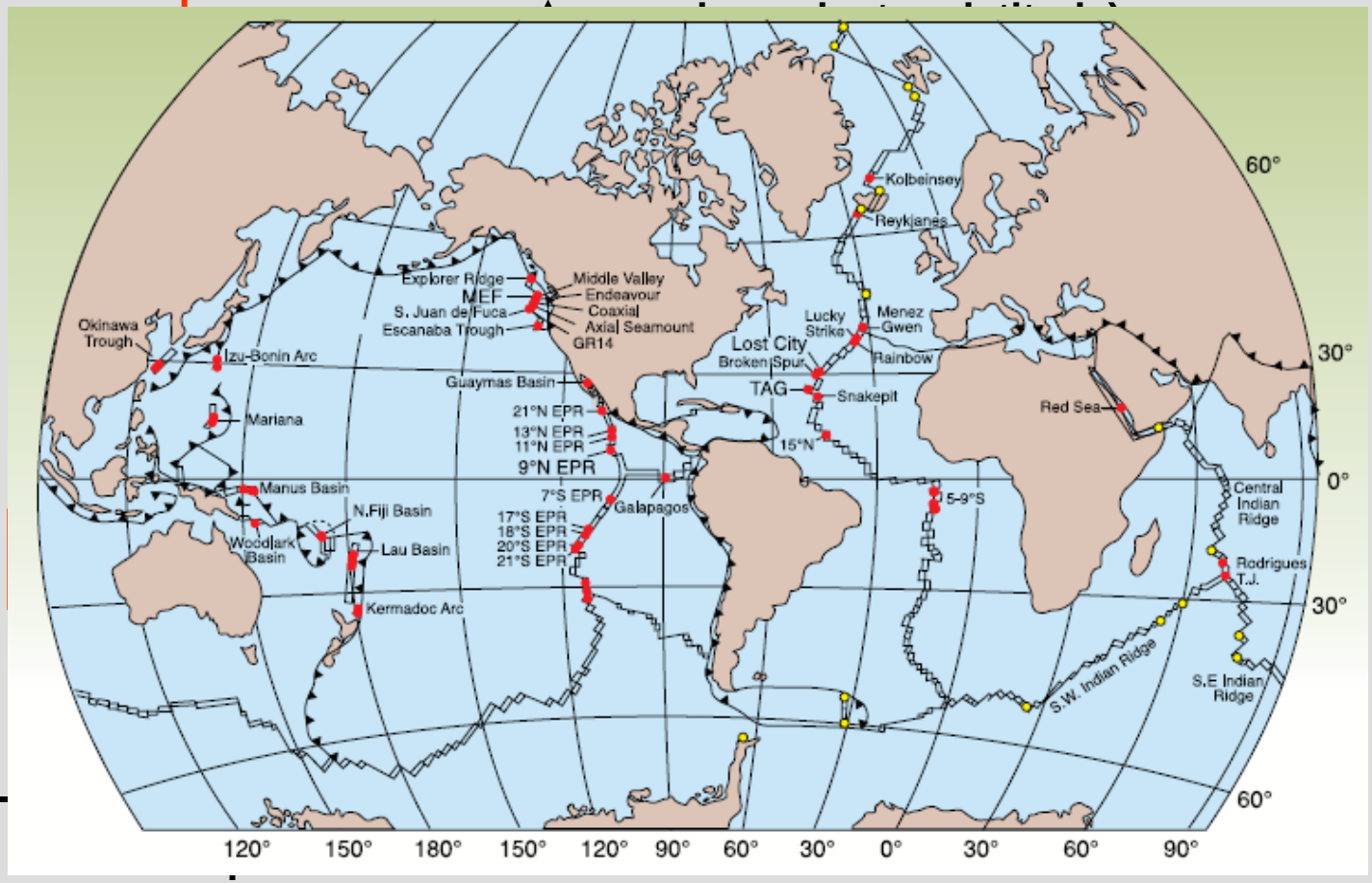
# Differences of spatio-temporal continuity of energy sources

**Geochemical sources**
**(e.g. hydrothermal vents)**

Time

**Solar radiation**
**(Intensity and continuity**

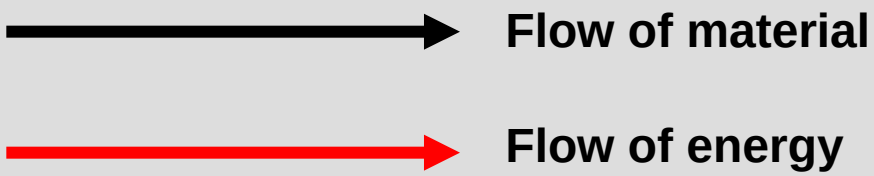
Time




Source: Tivey 2007

# Characteristics of chemoautotrophic processes

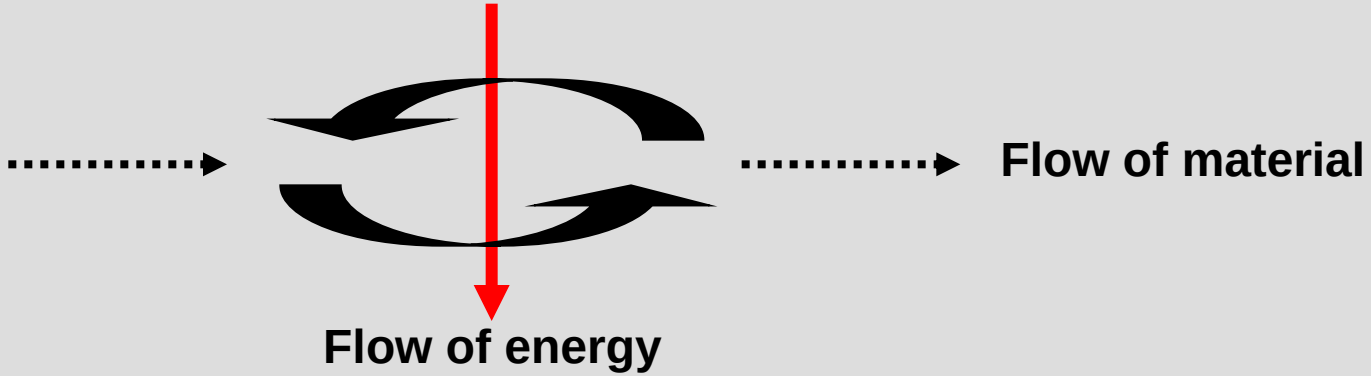
- Energy flow depends on material flows




- Discontinuous and spatial heterogeneous sources
- High diversity of energy sources
- Requires high primary metabolic diversity, adaptation to large bandwidth of abiotic conditions (Temperature, pH ..), and to extreme long starvation periods.

# Characteristics of photoautotrophic processes

- Quantum energy flow from solar radiation increases the bandwidth for material recycling, in particular of oxygen

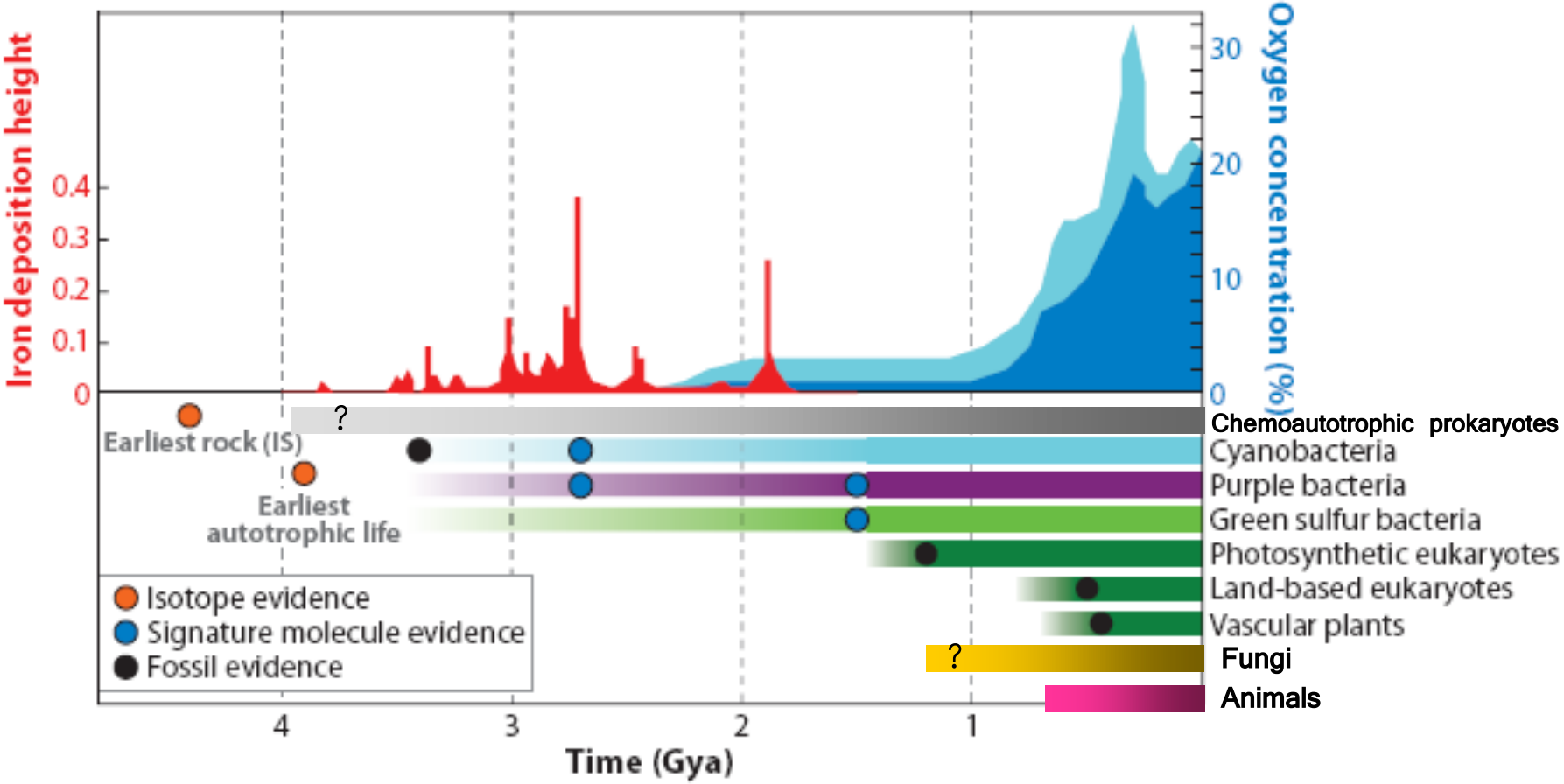



- Enables the development of multicellular organisms

- Energy availability depends on latitudinal conditions

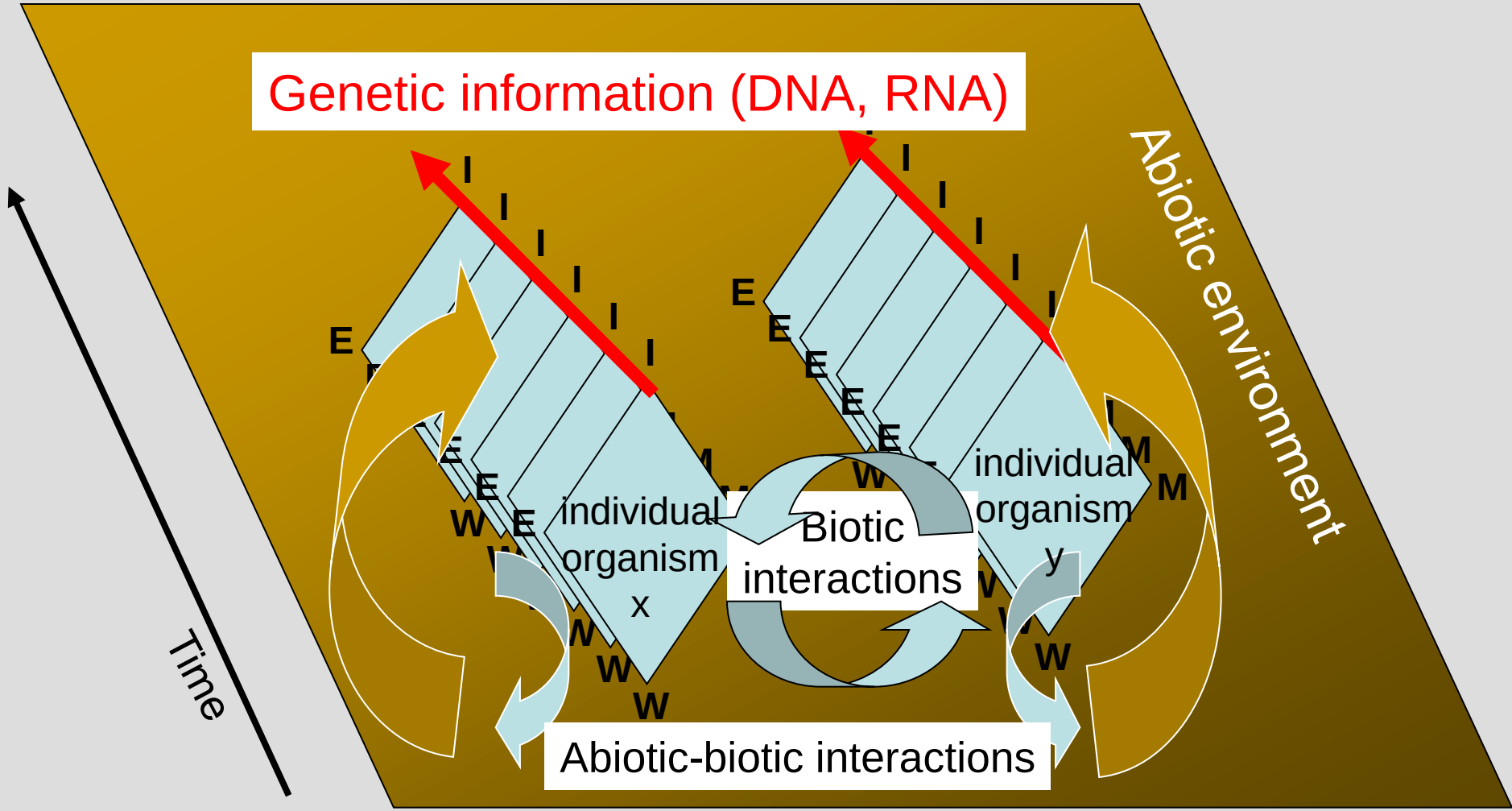
- Limits the primary metabolic diversity, increases phenotypic and structural diversity

# However, both principles remained over the whole history of evolution

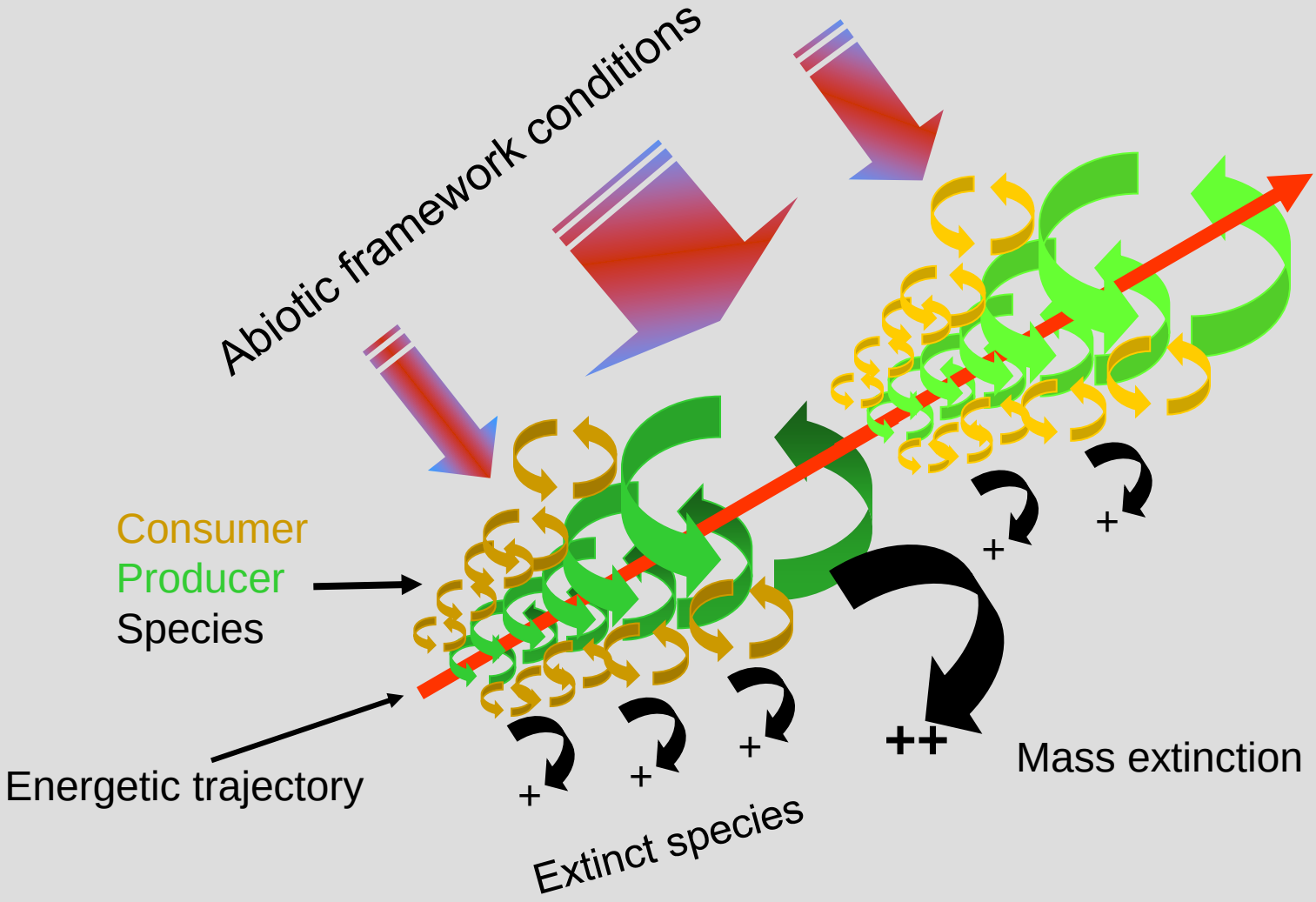



**Source: Hohmann-Marriott & Blankenship 2011, modified**

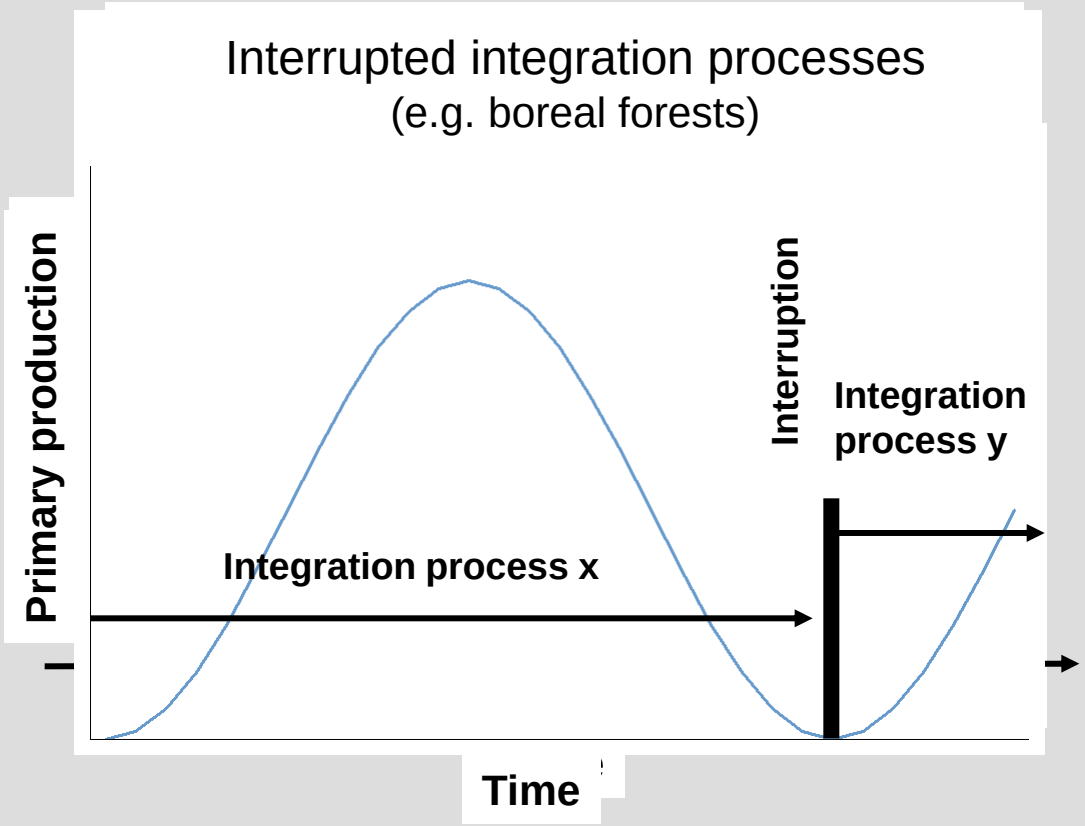
Hence, the evolution of a genetic germ line depends on the adaptation of subsequent phenotypes to abiotic and biotic conditions,



# and the integration into the flows of energy and materials on an “occupied table”



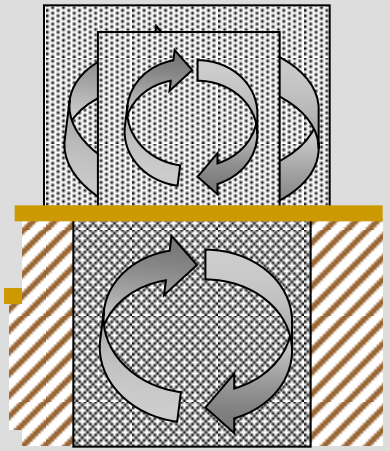
# The temporal pattern of integration processes provides insights into peculiarities of ecosystems




**Consequences:**

**- Reduced biodiversity, interspecific constraints variable (low numbers of iteration cycles)**

**- Deep organic soils (because of high volume of organic residuals at interruptions)**



# Basic rules of integration processes

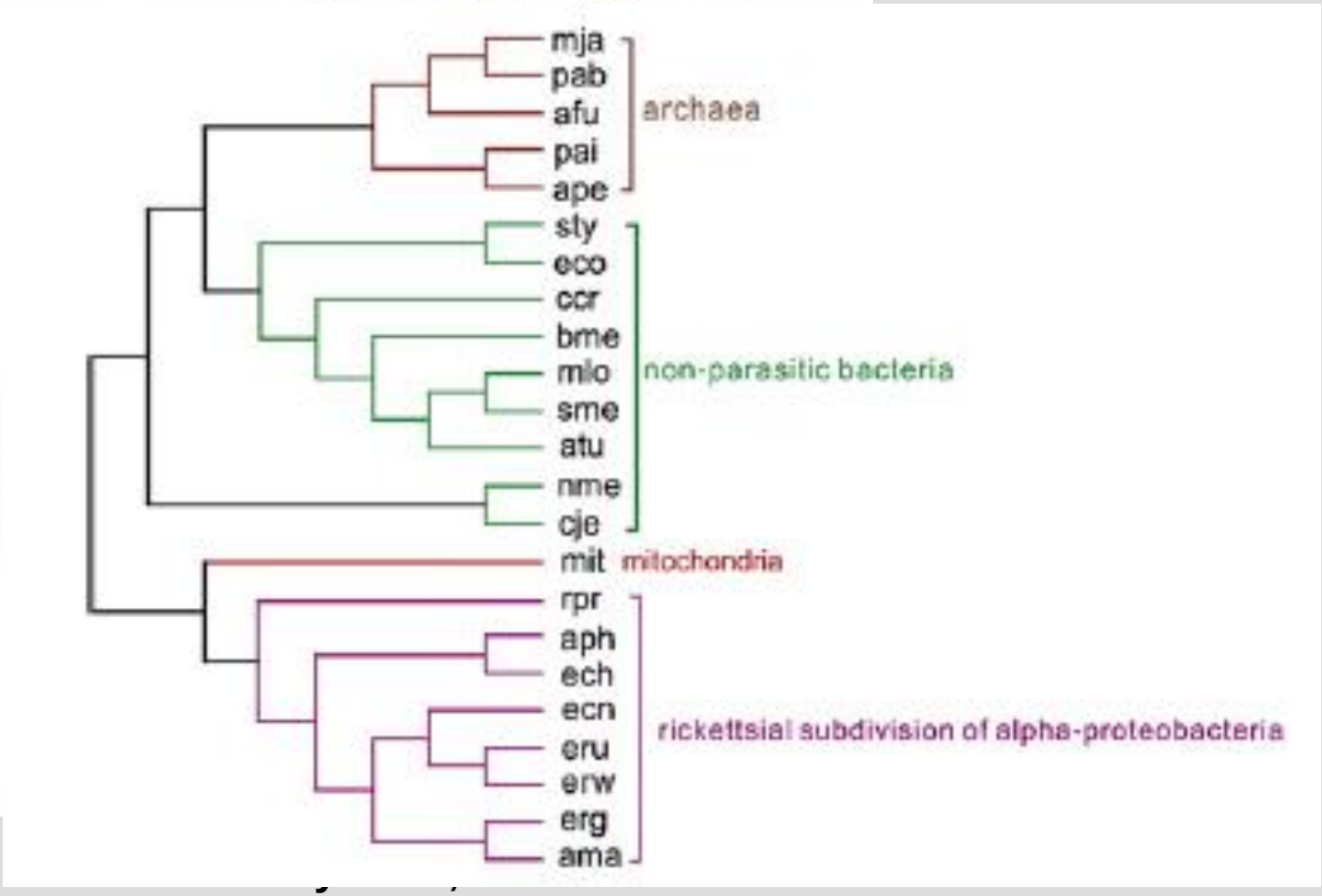
a) Each organism enters into the integration process at individual scale, based on the individual tendency to improve the gains of energy and materials - as also to reduce losses

b) Integration becomes successful if energetic and material flows are kept dynamically in balance for all involved organisms by cooperation; otherwise it fails

c) Integration operates over n-dimensional interactions, and long term iteration cycles without predictable results

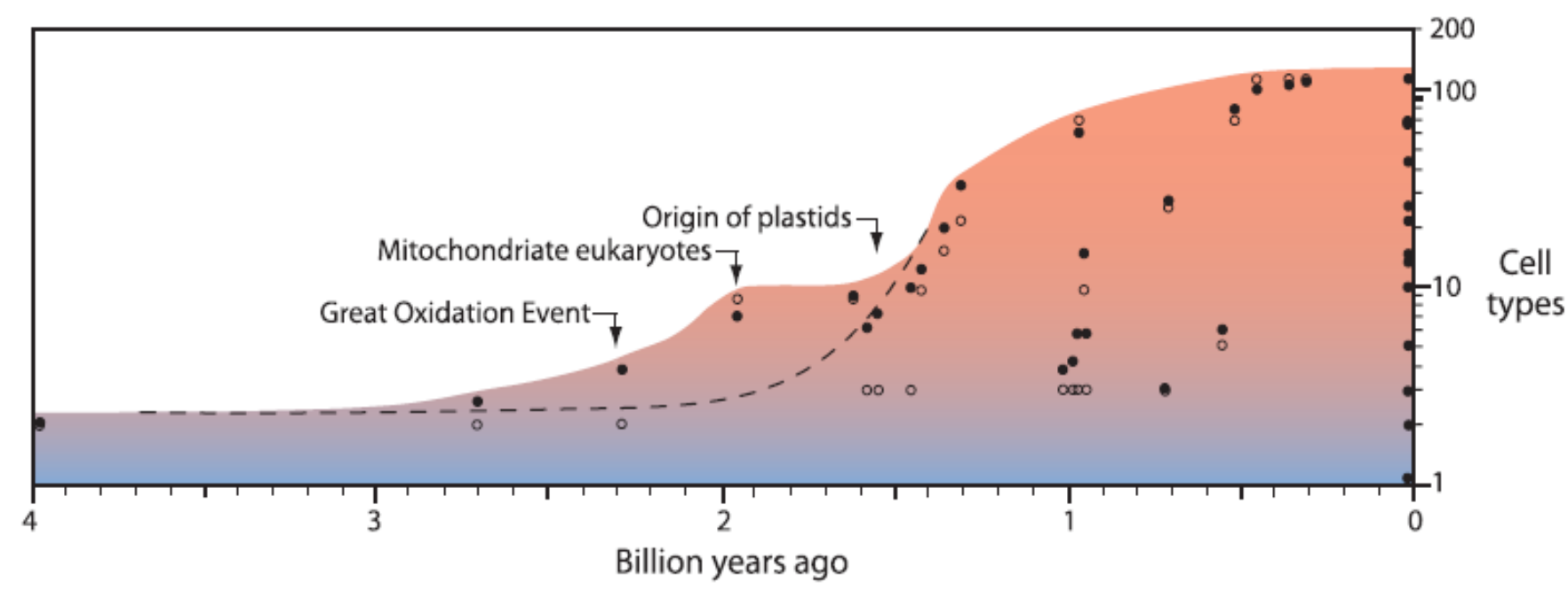
d) Each disturbance or interruption starts a new integration process

# Example of a successful integration in the early periods of evolution – the endosymbiosis of mitochondria, and an opposite outcome



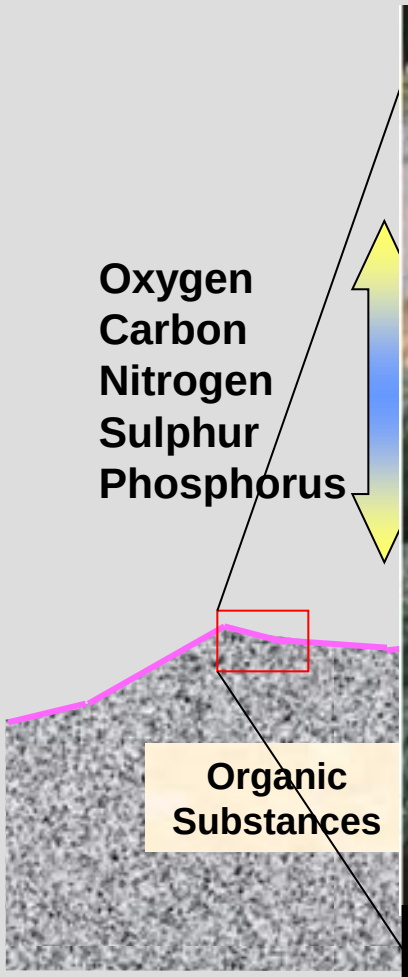

**Chang et al. 2010**

# Example of differentiation and integration of functionally different cells in multicellular organisms




Source: Hedges et al. 2004

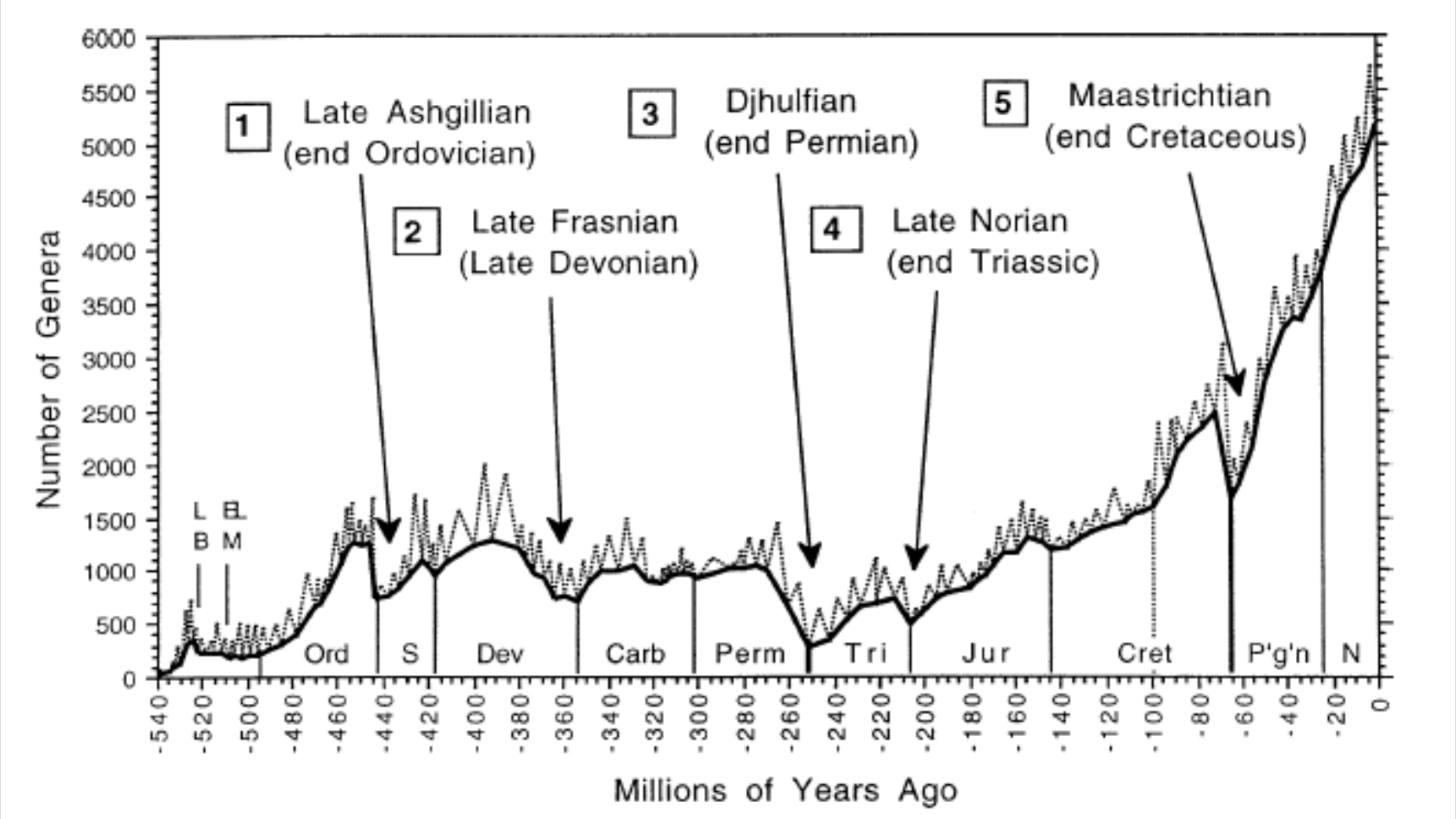
# Example of integration of organisms in ecosystems and emergent feedback effects




Source: Riding 2011

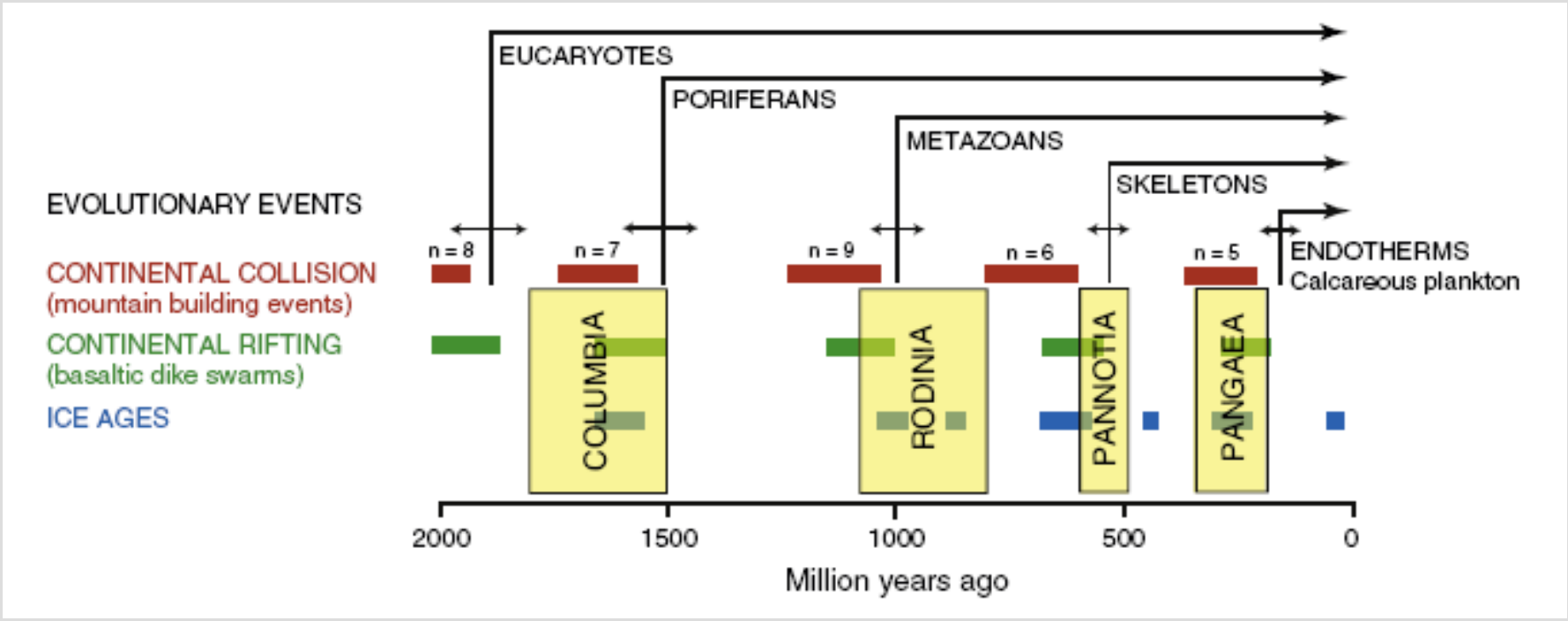
# Abiotic framework conditions

# Why was evolution so bumpy – also beyond the “big fives” ?



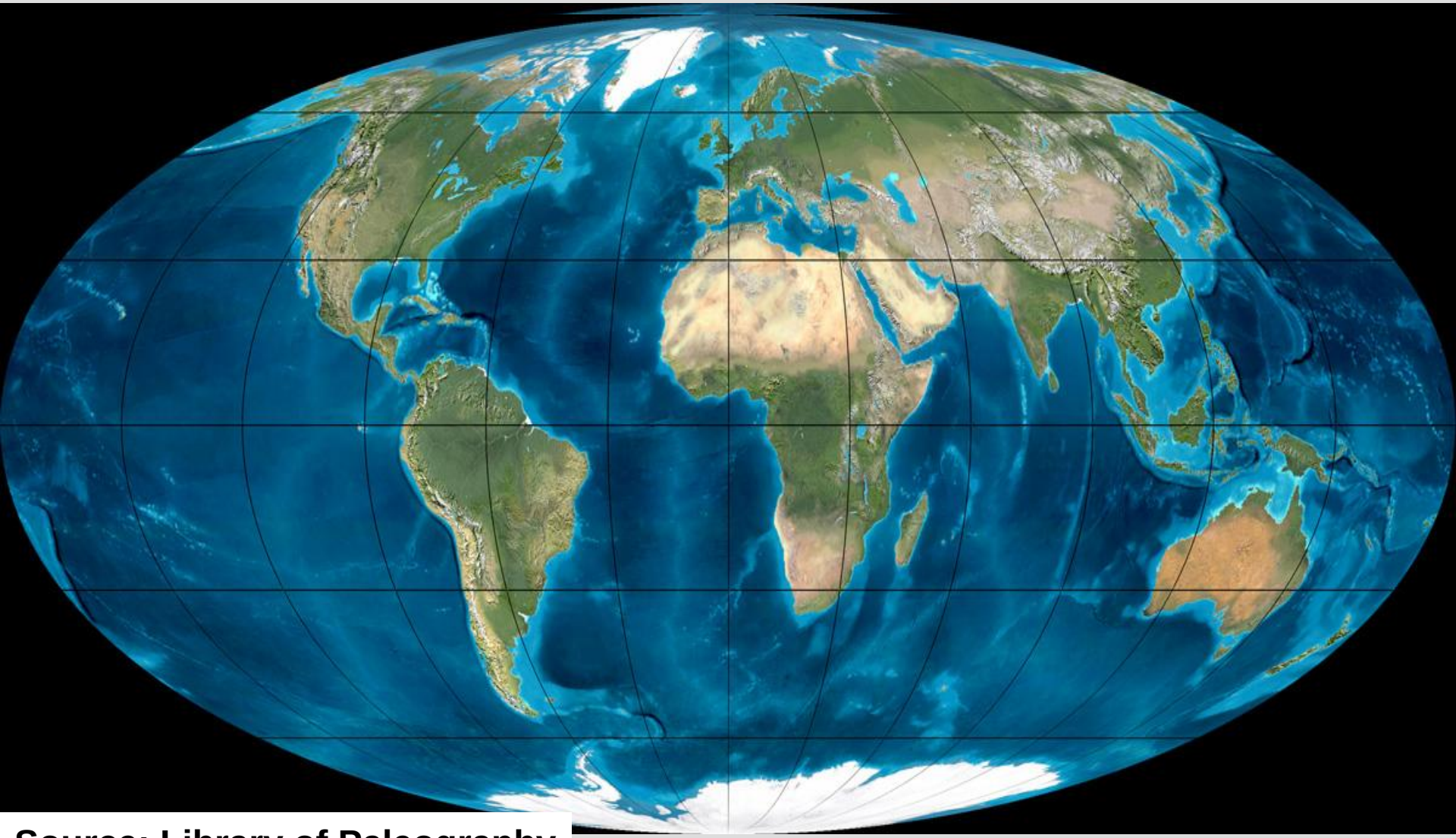

**Source: Bambach et al. 2004**

# Some ideas from the rough picture of abiotic and biotic timelines



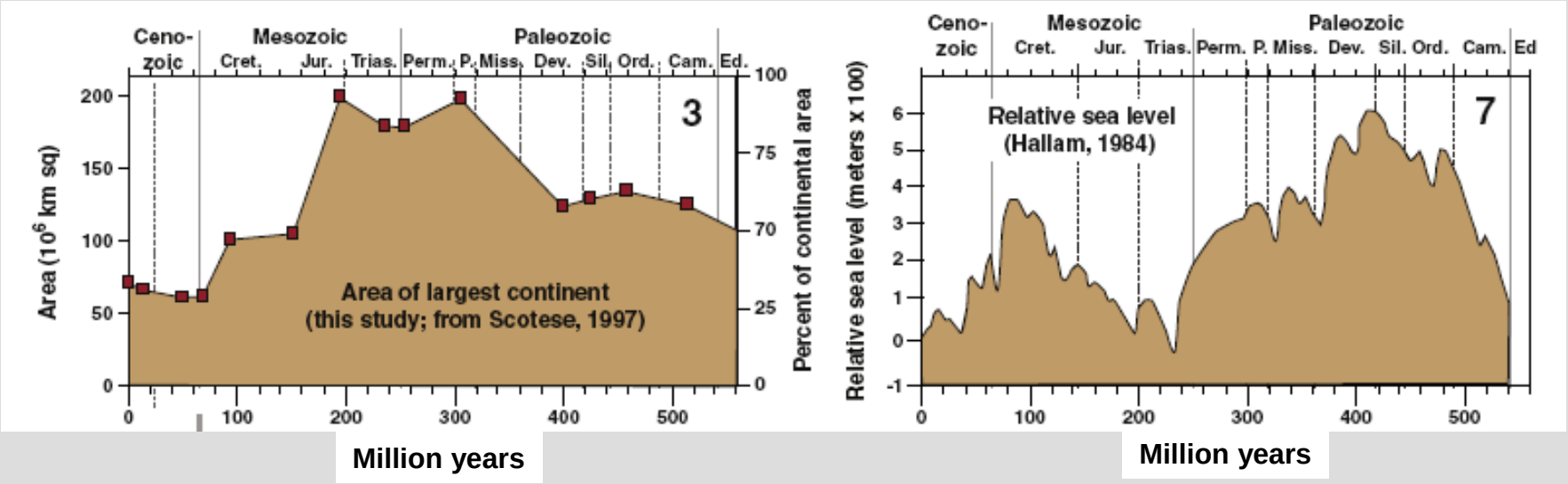

**Source: Nance et al. 2013**

# Multidimensional changes of abiotic factors caused by geodynamics,



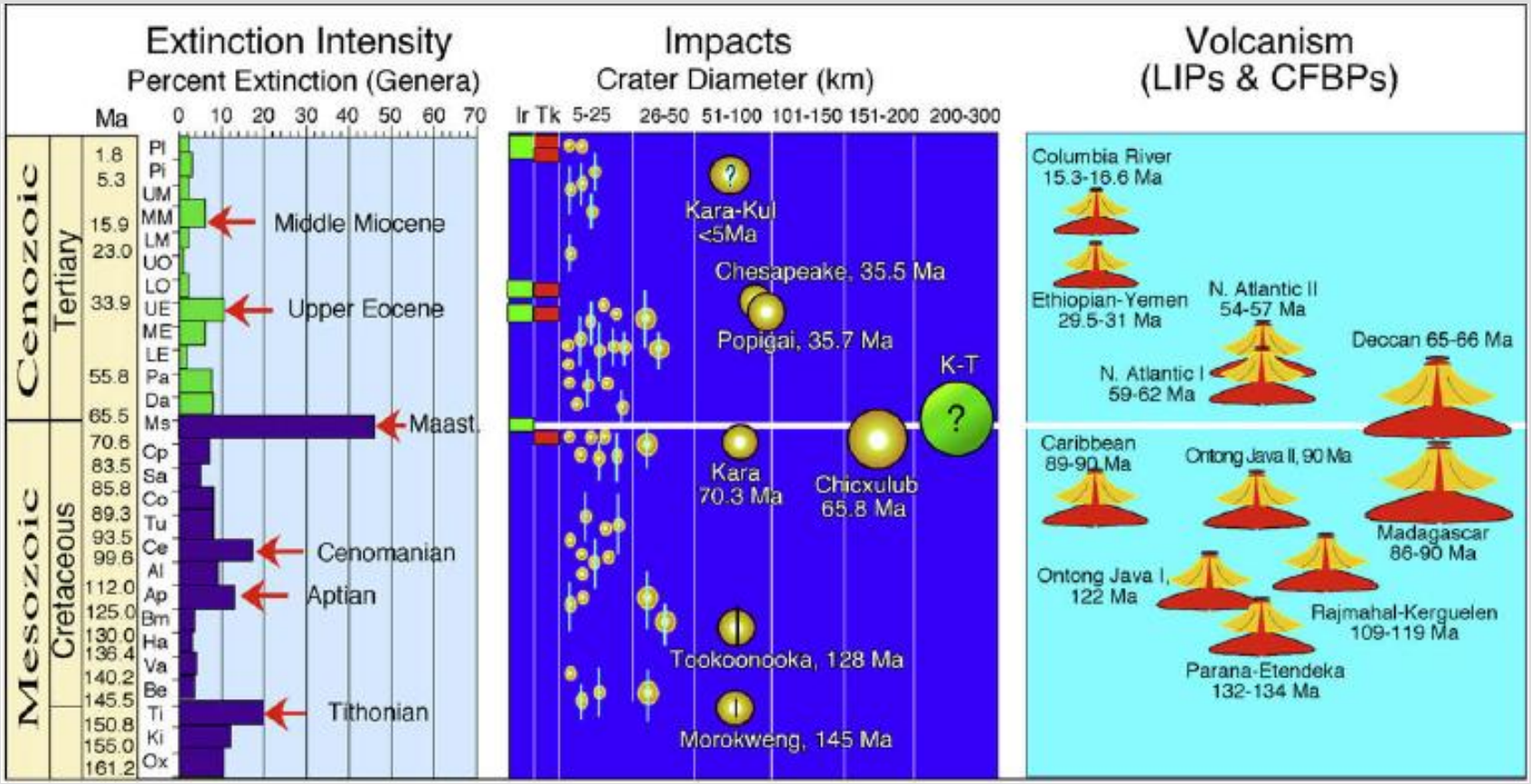
**Source: Library of Paleography**

# with serious consequences for land-sea relationships




**Source: Bradley 2011**

# Unpredictable „knock-outs“ - volcanic eruptions and meteorite impacts?

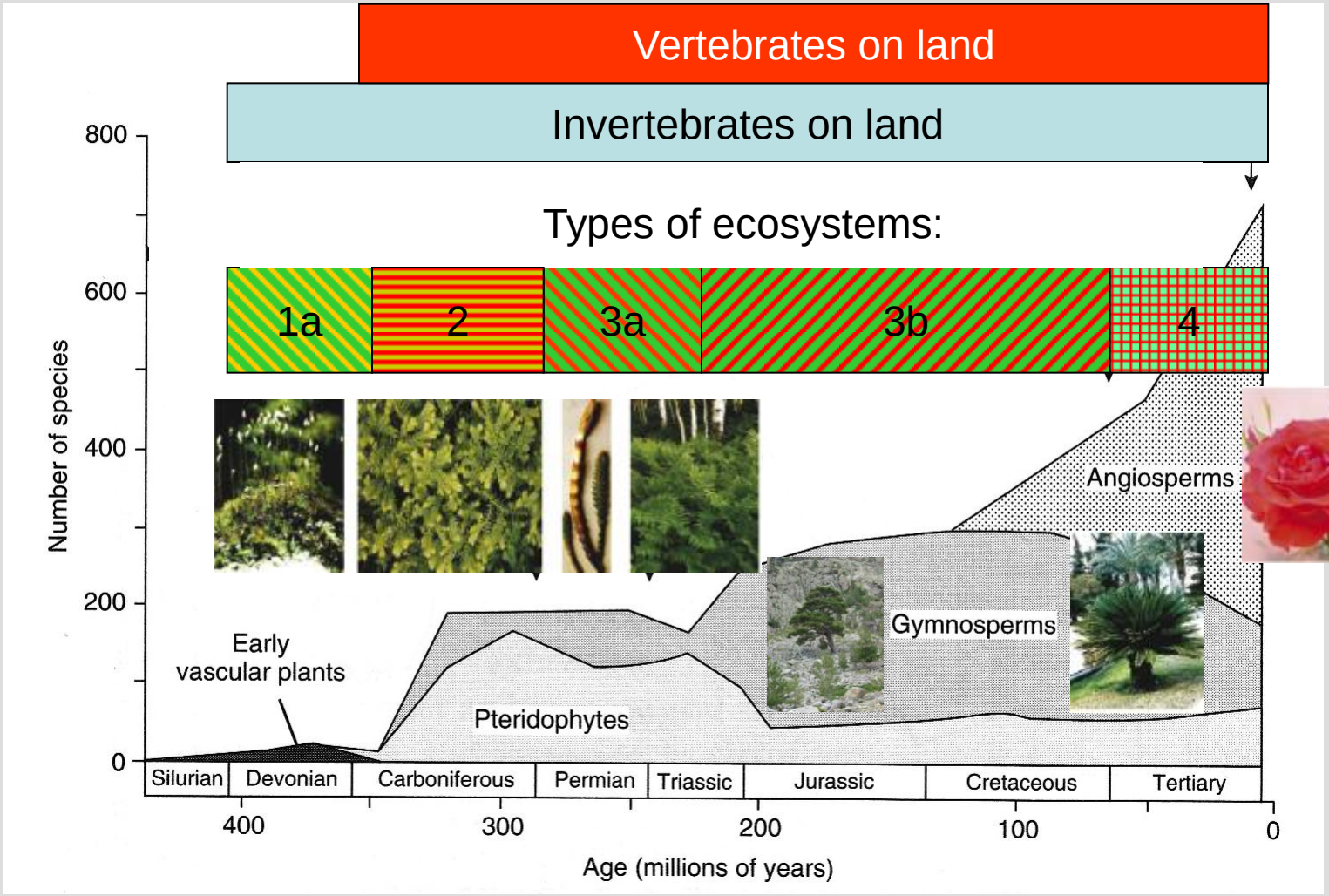



LIP = large igneous provinces
CFBP = continental flood basalt pr.

**Source: Keller 2008**

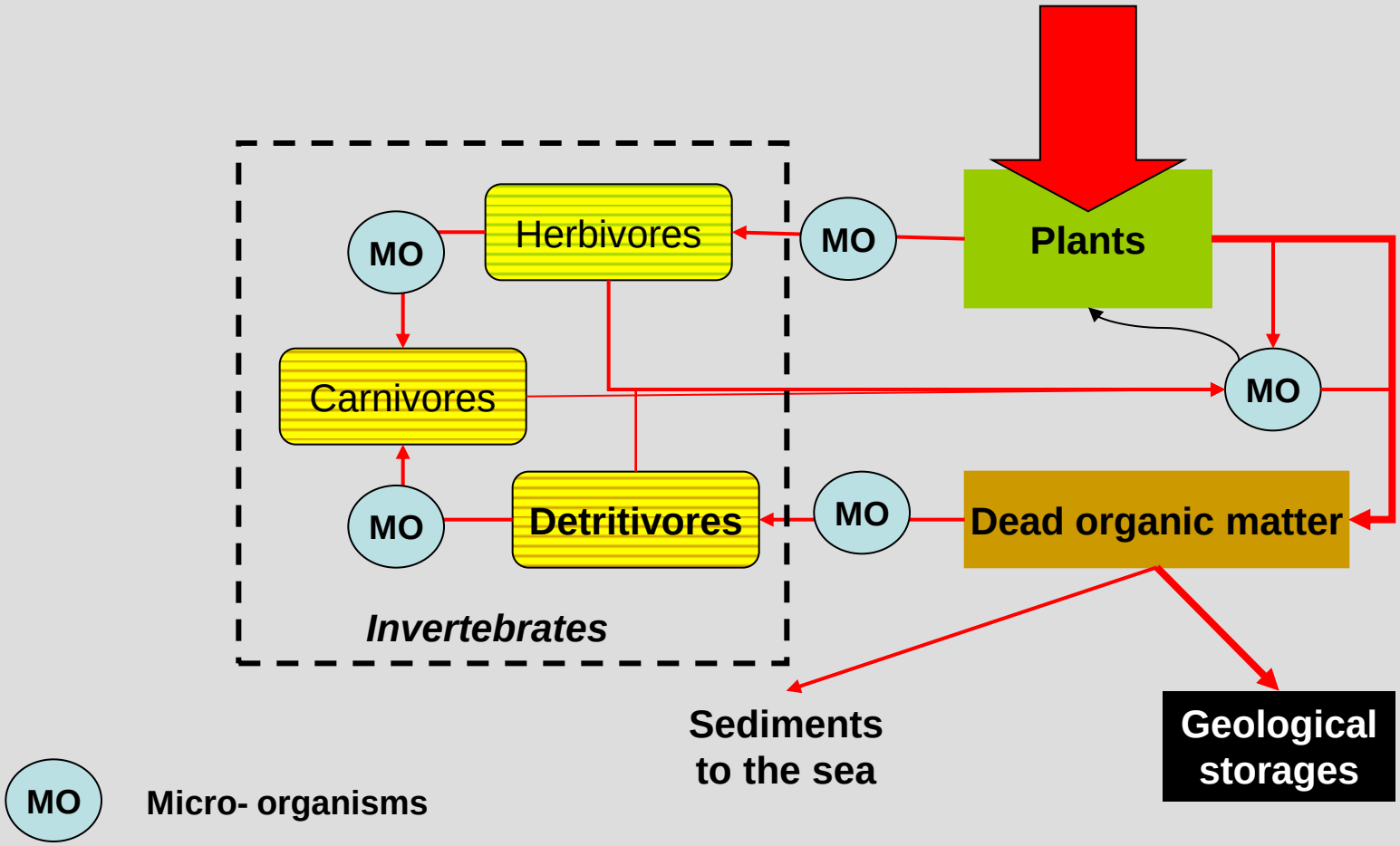
# Evolution of terrestrial ecosystems – the frameworks for human evolution

# Integration in evolutionary time scales – the development of terrestrial ecosystems

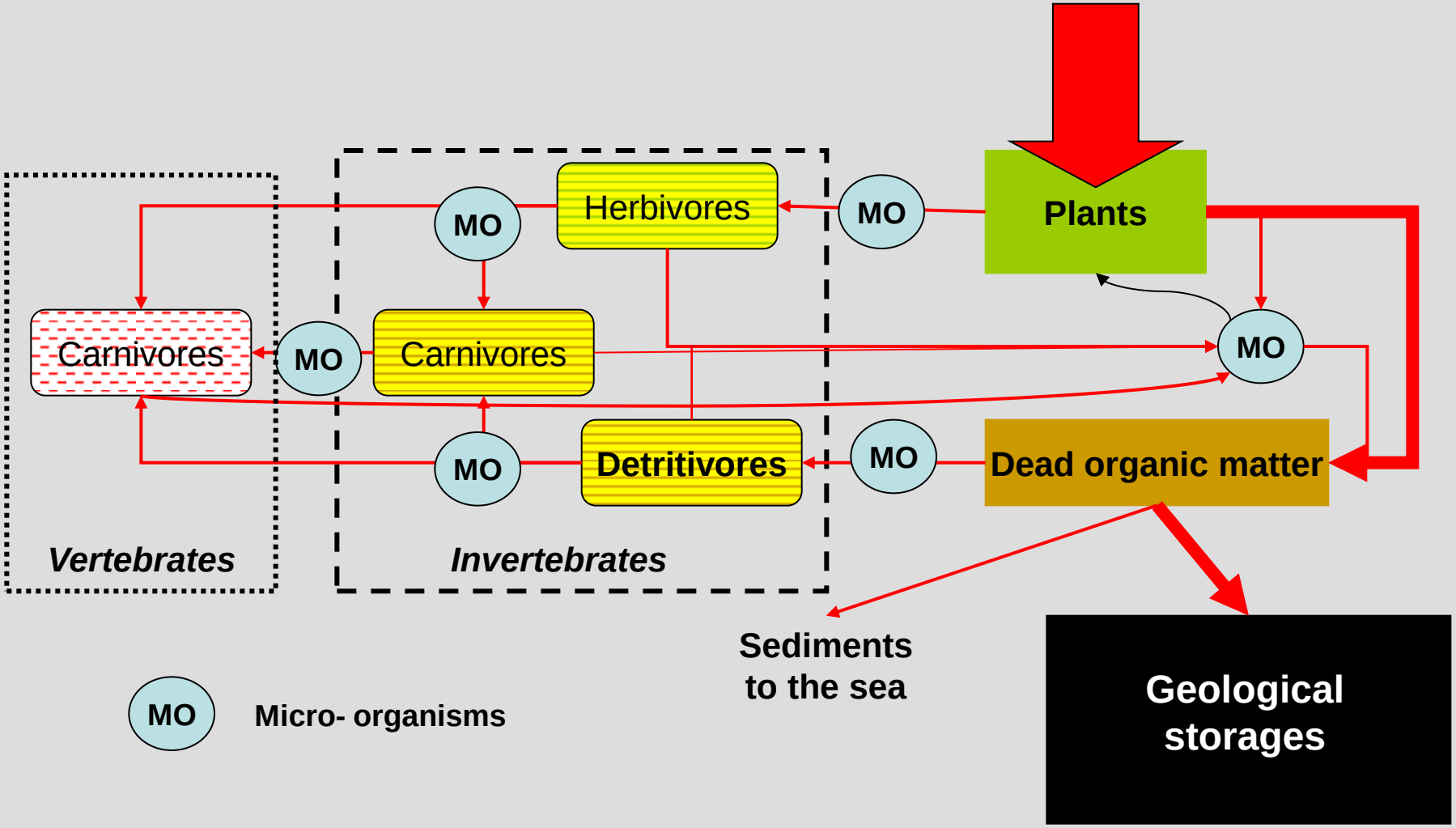



Sources: Willis & McEllwain 2002; Langdale 2008; modified

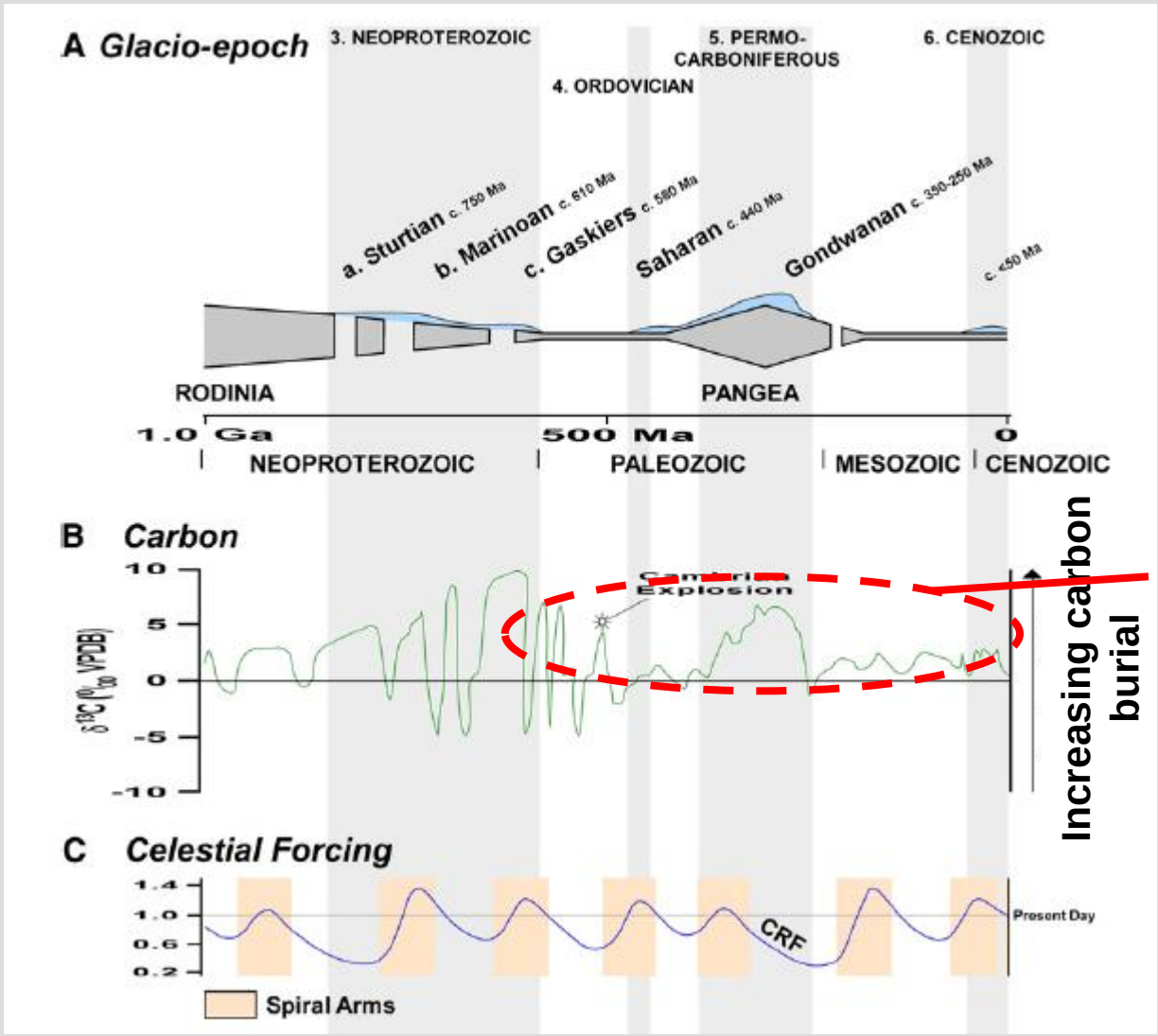
# Ecosystems 1 - Invertebrates



# Ecosystems 2 – Invertebrates and first carnivore vertebrates



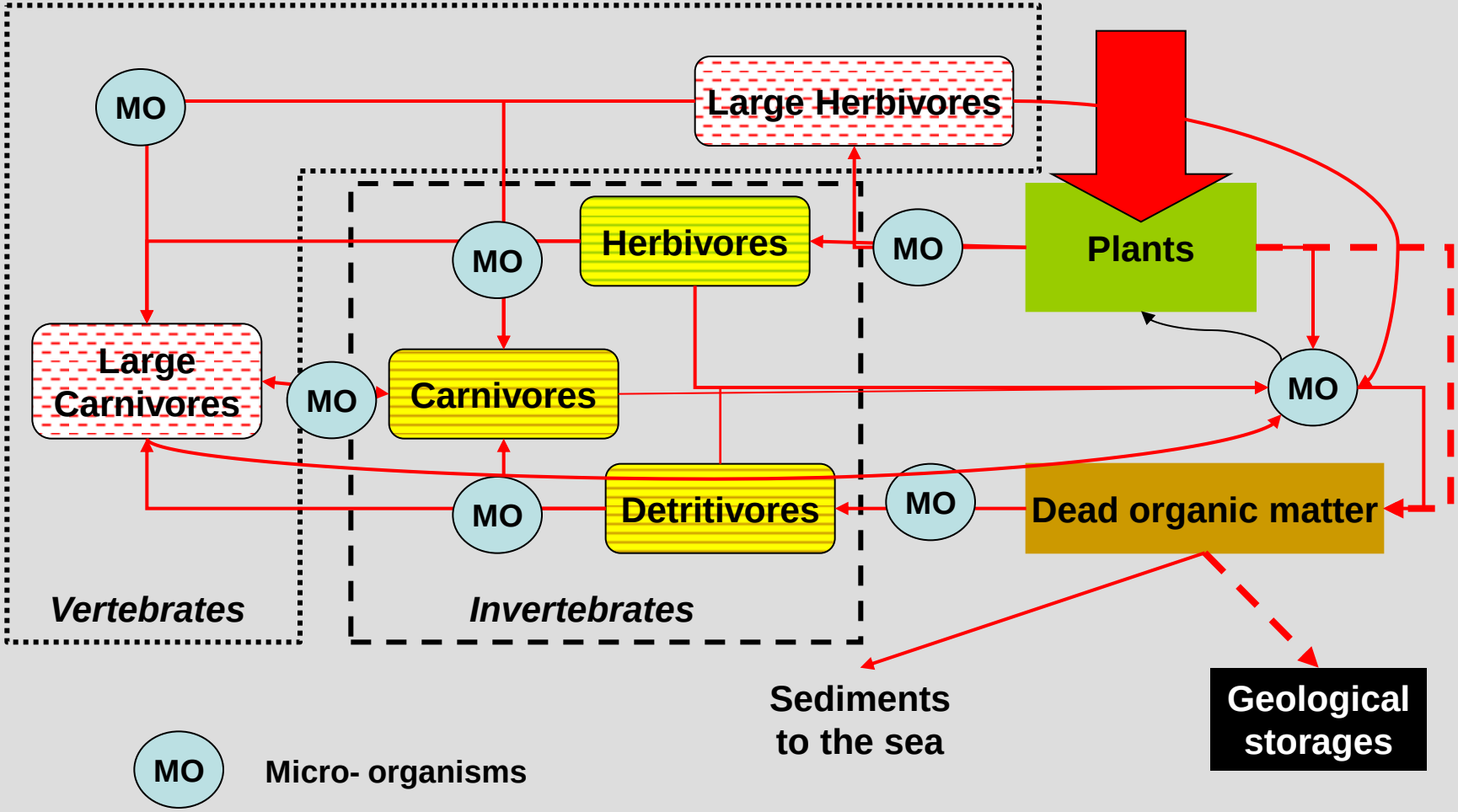
# Feedbacks and consequences of ecosystem development



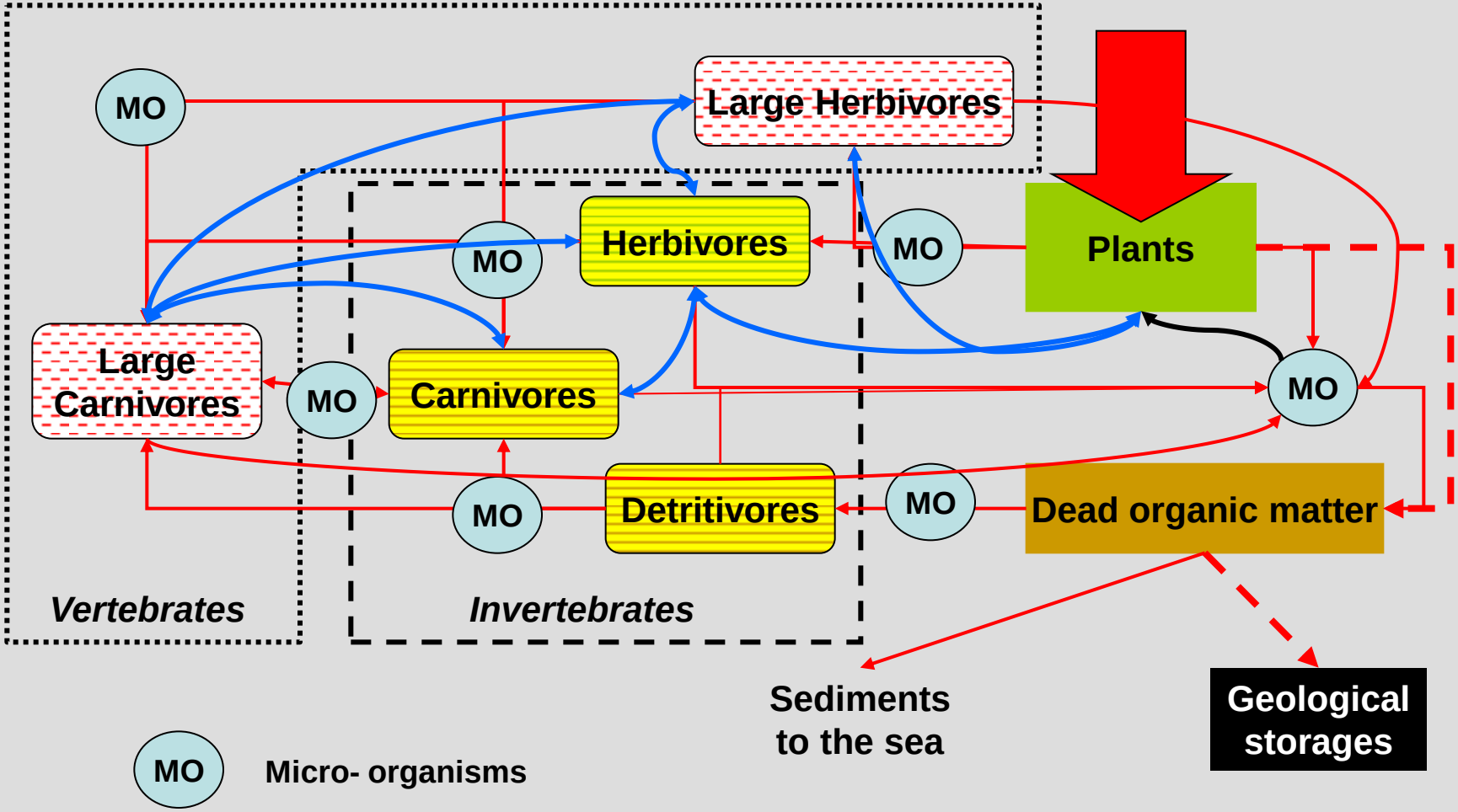

„carbon heritage“

**Source: Eyles 2008**

# Ecosystems 3 – Development and scaling up of vertebrate herbivores towards dinosaurs



# Ecosystems 4 – Increase of information regulation in ecosystems caused by appearance of flowering plants



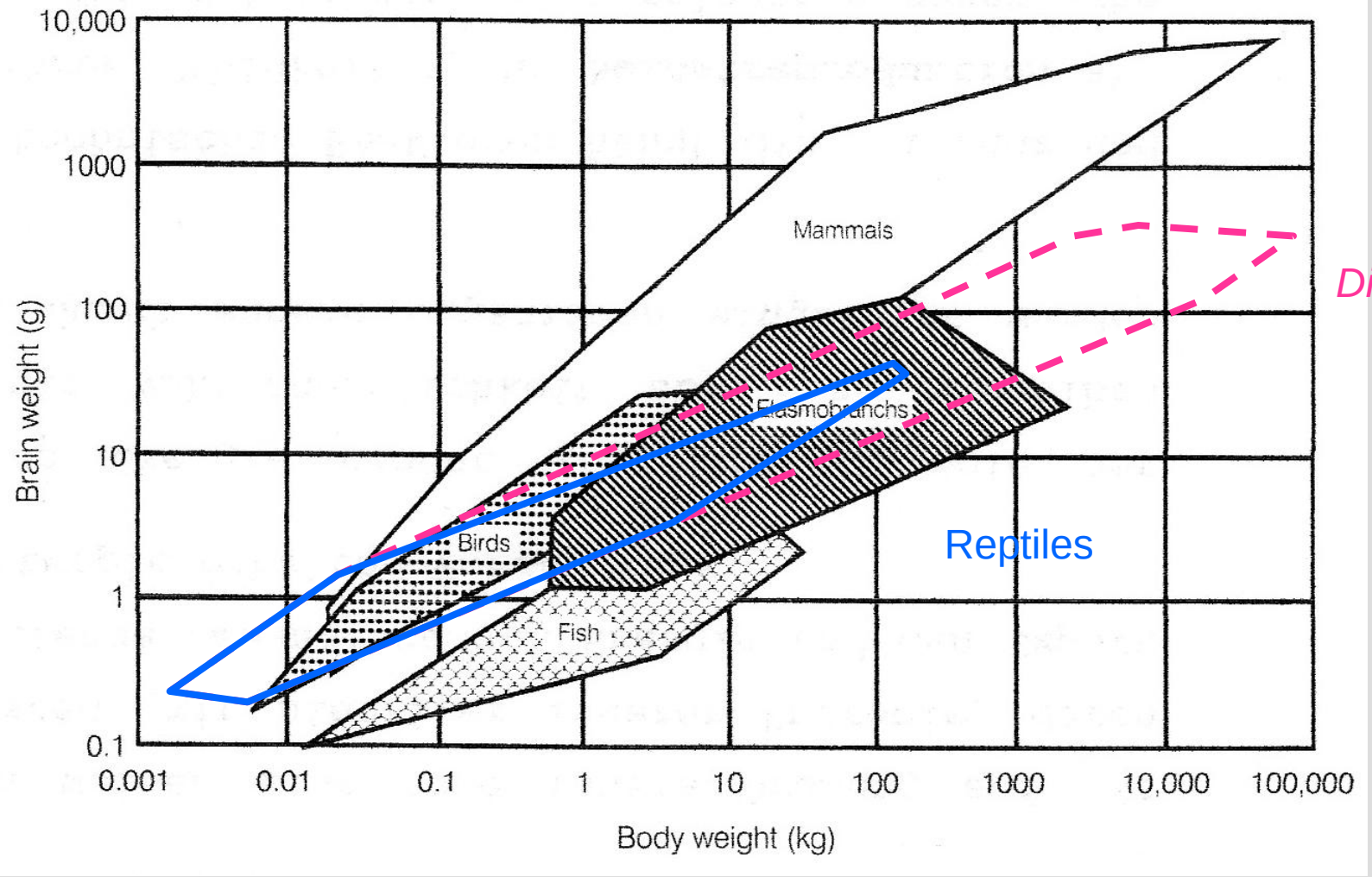
# Bee‘s secret knowledge – the different interactions in unspecific and specific plant information systems,

**“Forest honey” – from excreta of randomly tree sucking wood lice with no energetic benefit for the plant Ecosystem 3 (cretaceous) mode**

**Source: Frank Mikley**

**“Flower honey” – from nectar, offered directly by plant signals (flowers) in exchange to pollination Ecosystem 4 (tertiary) mode**

# and the consequences for vertebrate brain evolution




Source: Helfman et al. 2009, modified after Jerison 2004

# Some lessons learned about evolutionary progress and success

- Biological process can modify, but not overcome abiotic processes by selective use and autonomous storage of energy
- Micro-organisms are ubiquitous regulators of ecological processes
- Top consumers – involved in networks of organisms with similar capabilities - can block the evolution of potential competitors with higher mental capacities (e.g. dinosaur/mammal worlds)
- Successful – from the perspective of long term evolution - are “scavengers”, the detritivores (e.g. bacteria, fungi, mites, earthworms, millipedes)

# Aspects of evolution which can be a model at system level

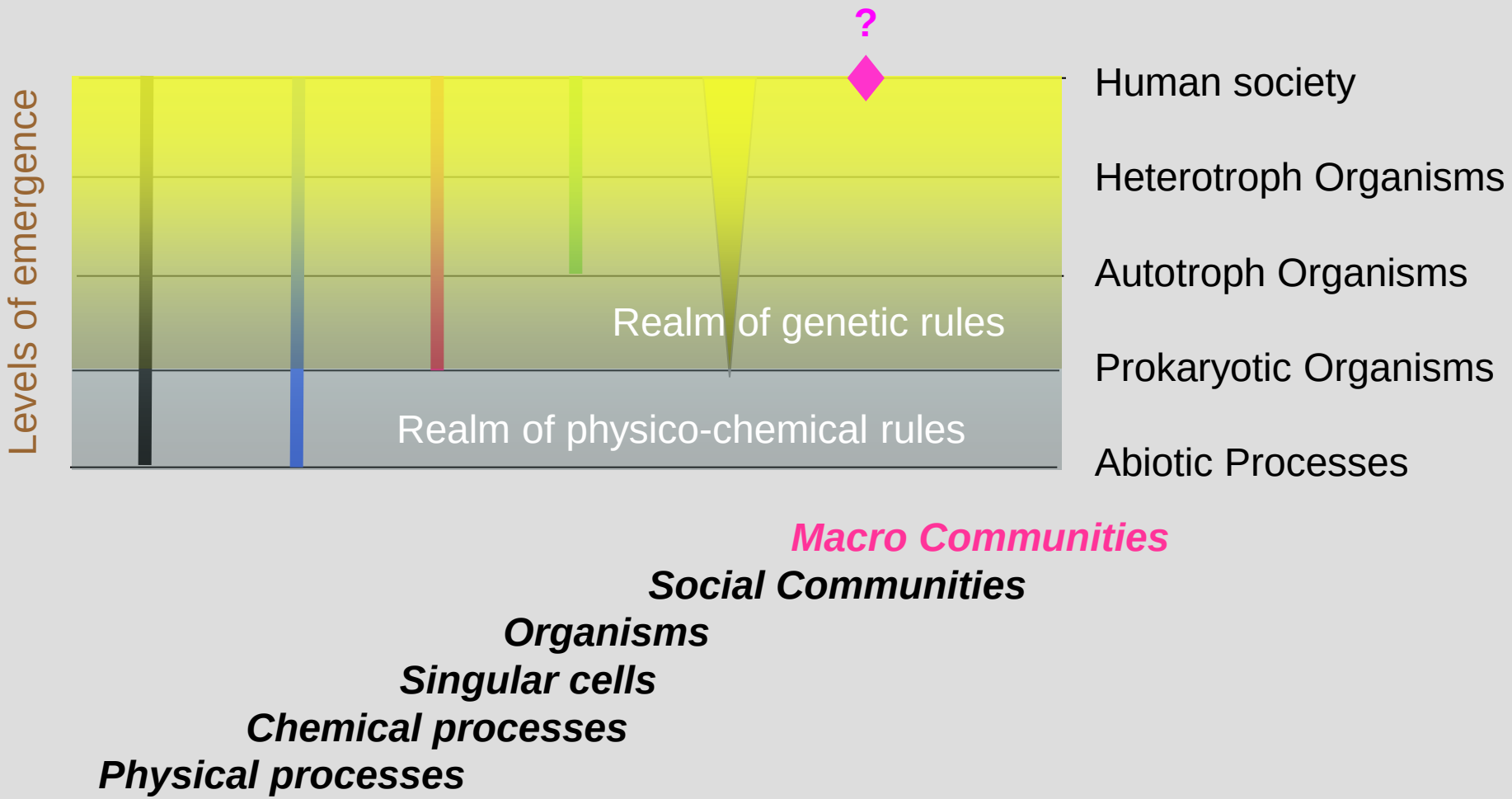
- Self organisation of processes, directed away from thermodynamic equilibrium (“uphill”)
- Energy supply based on long term available energy sources
- Integration into systems is governed by the rules of balanced flows of energy and recycling of material
- Spatial structures are designed to fulfil multiple tasks
- Unexpected disturbances are compensated by redundancy

# Where we have to be careful to use evolution as a model

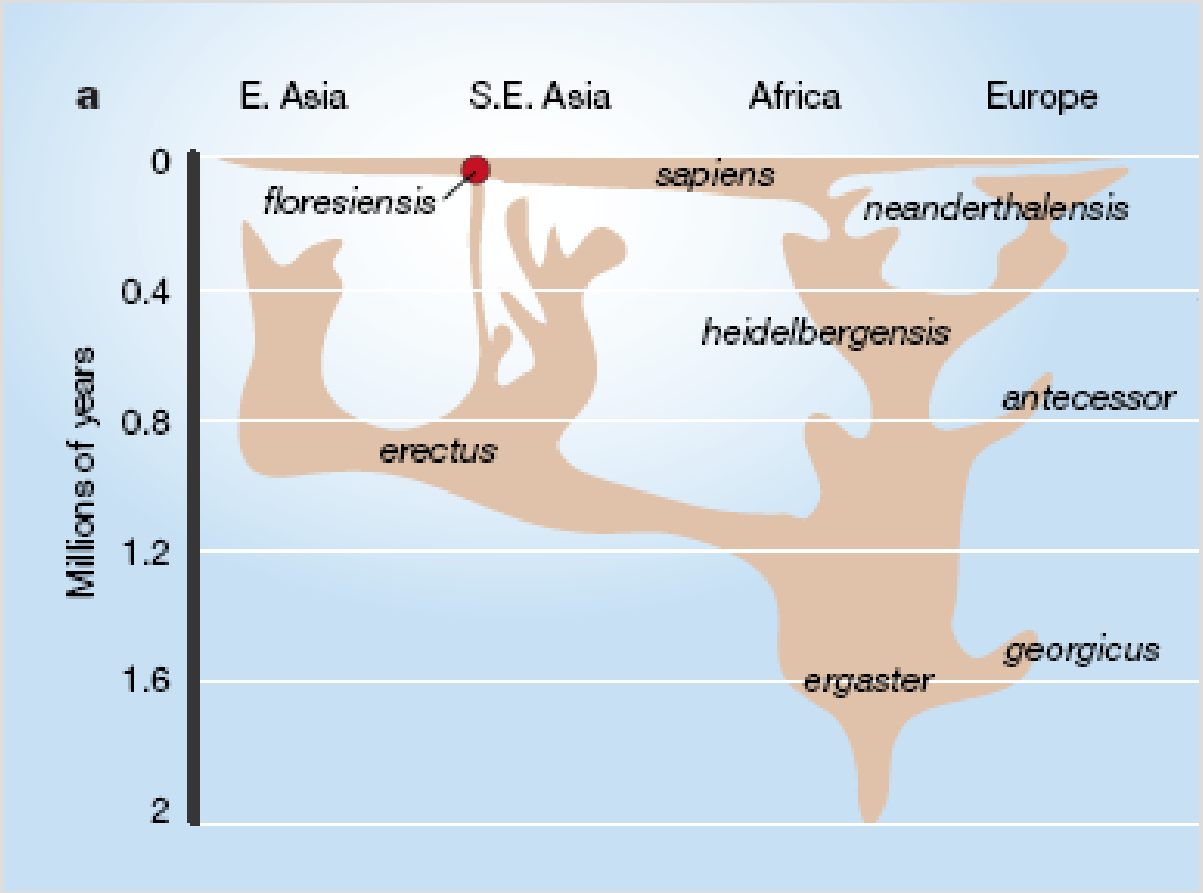
- Selection of energy sources beyond food: It should be focussed on long term energy flows, complementary to biological energy sources (in quality and spatial distribution)
- Using biological processes as arguments to undermine human ethic rules
- In transformation of landuse practices to regions with different framework conditions

# Commons and peculiarities of human evolution

# The challenge for long term self organization of human societies



# Humans transmitted technologic skills to overcome environmental constraints..

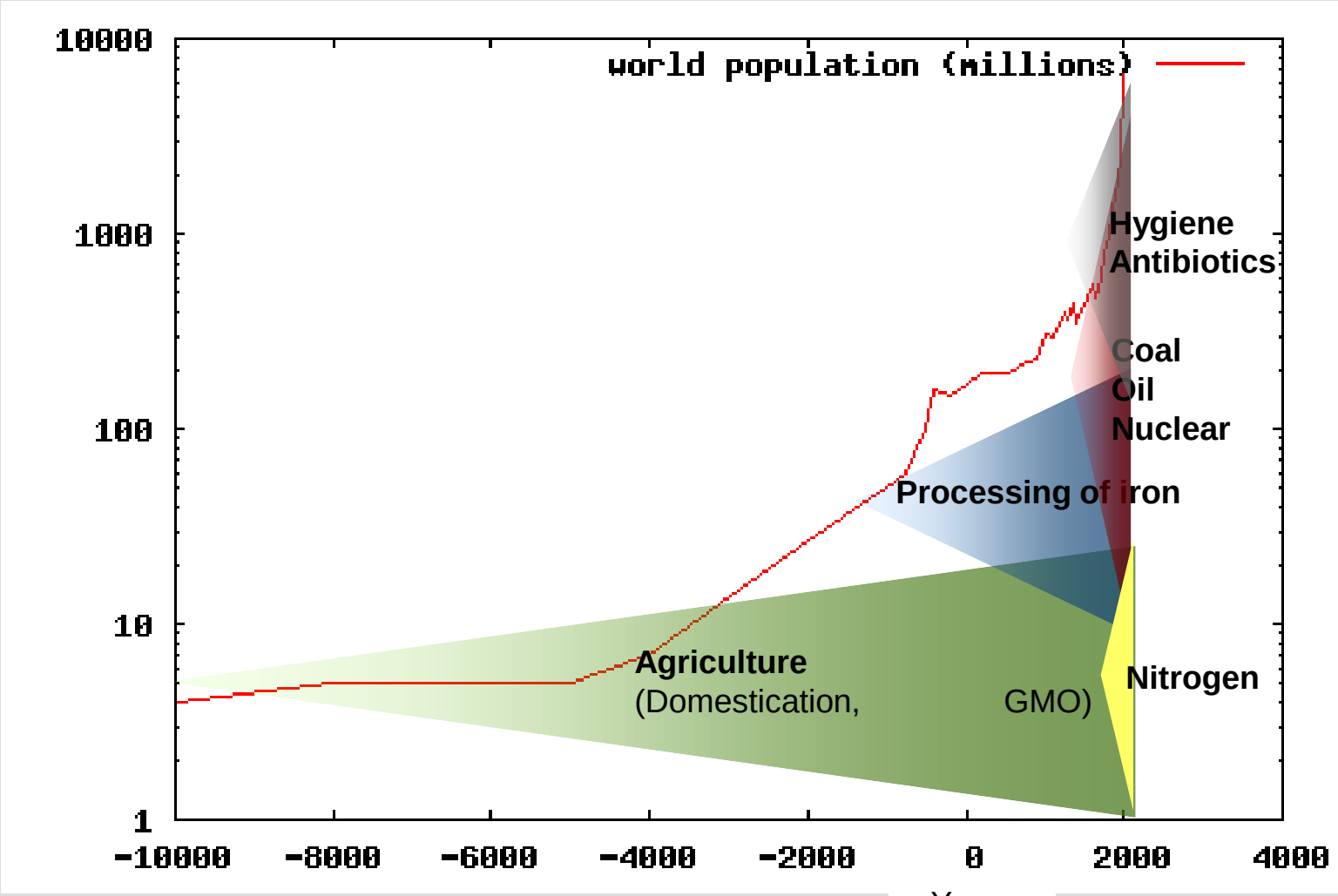



**Fire**

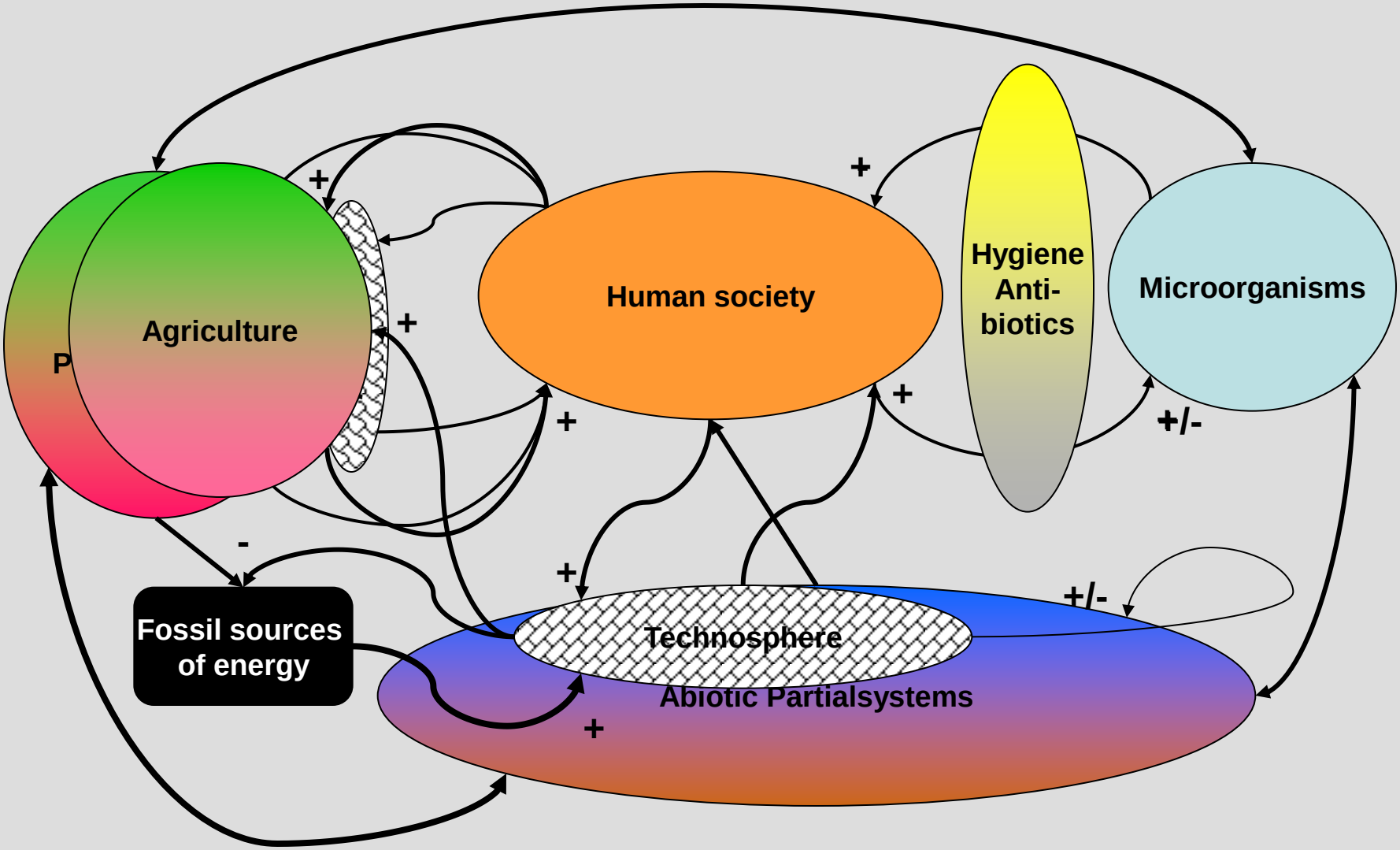
**Stone artefacts**

Source: Lahr & Foley 2004, modified

# with increasing speed and diversity - and dimensions of global human population



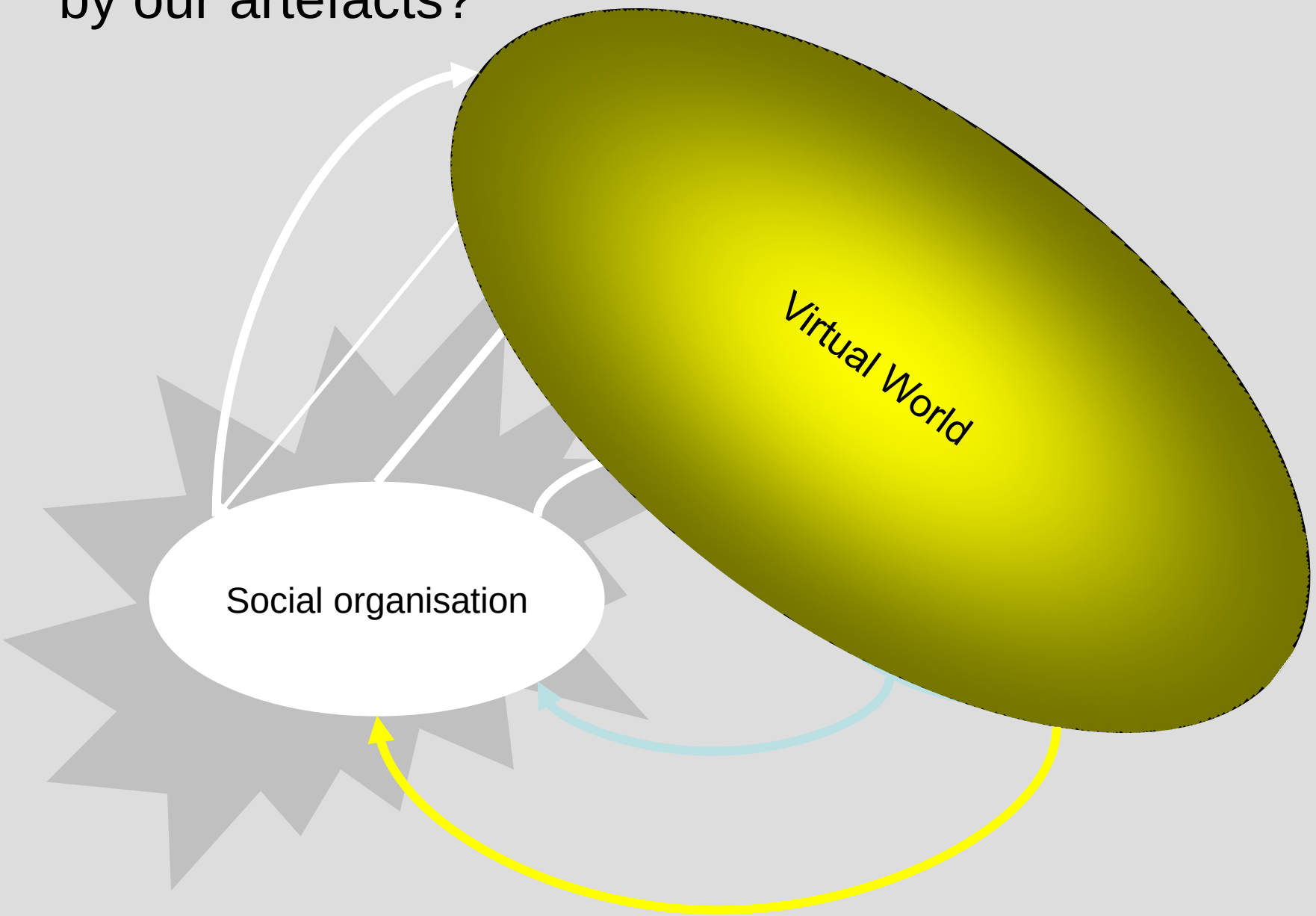
# Systemic effects of the efforts to overcome environmental constraints



# and on the remaining traits in human social habit

- Preference for direct and transformed growth (*loss of environmental regulators*)
- High attraction by strong energy sources (*beneficial in a constraint environment*)
- Strong tendency to avoid physiological losses of exergy (*important under unpredictable conditions*)
- Preference for unidirectional flow of material through human societies (*loss of ecological feedback loops*)
- Capacities for social adaptation are restricted to direct feedback loops
- High capacities to operate in complex local conditions

Is there a silent modification of social paradigms by our artefacts?



# One practical example – the Austrian „Alm“ Problem

Background: There is a intensive discussion between the EC and Austria about the „true“ dimensions of Alm-areas – with potential severe economic consequences for farmers.

a

# Neglected are the particular characteristics of such areas and the consequences of different survey methods.

- The peculiarities of such conditions are considered in the local land use rules and in the conscious experience of farmers
- “Objective” landcover survey methods, e.g. remote sensing, are well adapted to control landuse in areas with distinct borders. But, they are only applicable with restrictions for areas with fractal and fuzzy characteristics because of methodical and economic reasons.

# Main barriers to change the human habit

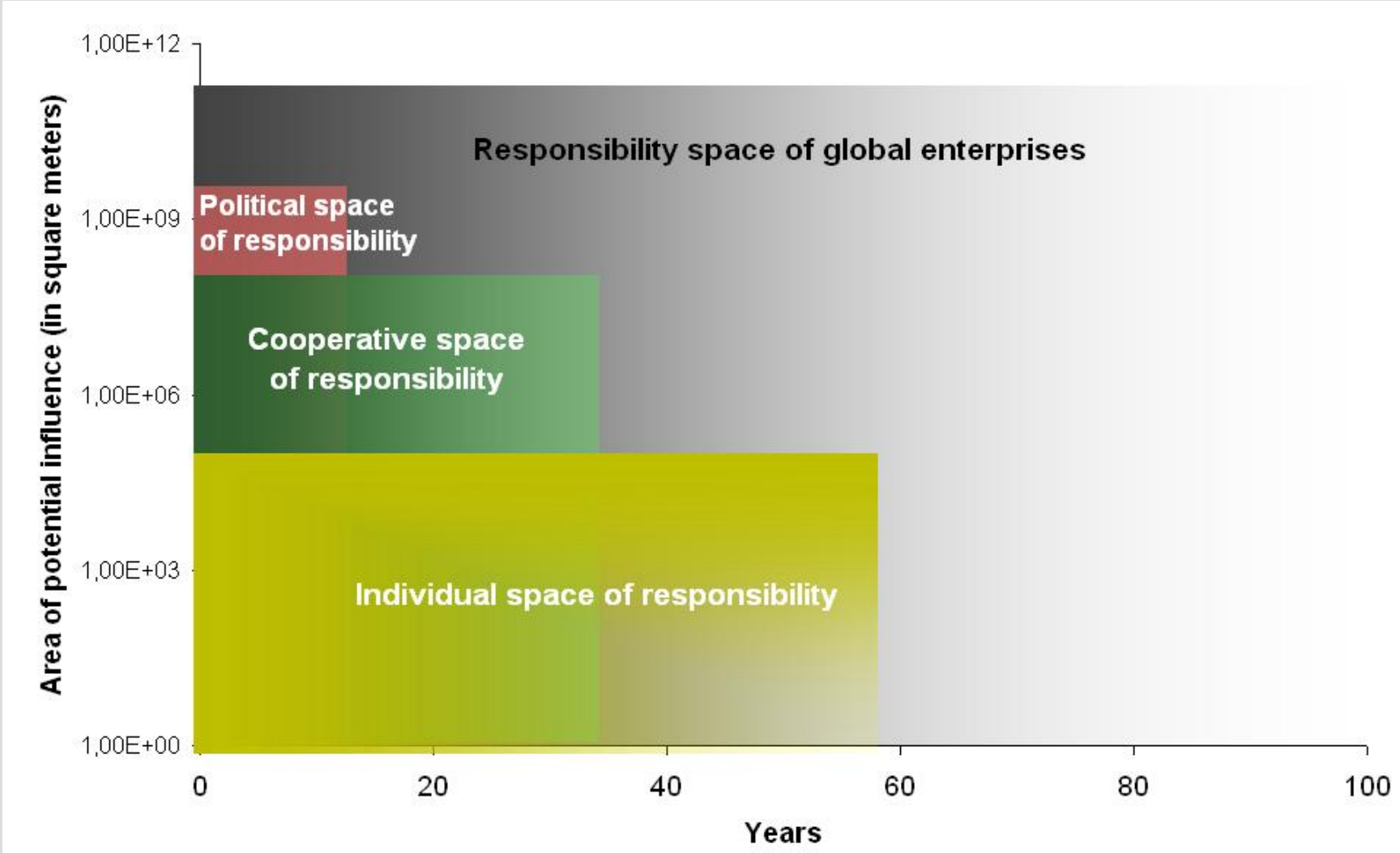
- Success of (evolutionary) misdirected behaviour within human competition
- Avoidance of unpredictabilities and uncertainties in environmental and social processes
- Existing dogmas and paradigms (also in science)
- Denial of human biological characteristics, and their influence on social solution capacities
- Attractiveness of technological solutions for compensation of required social solution

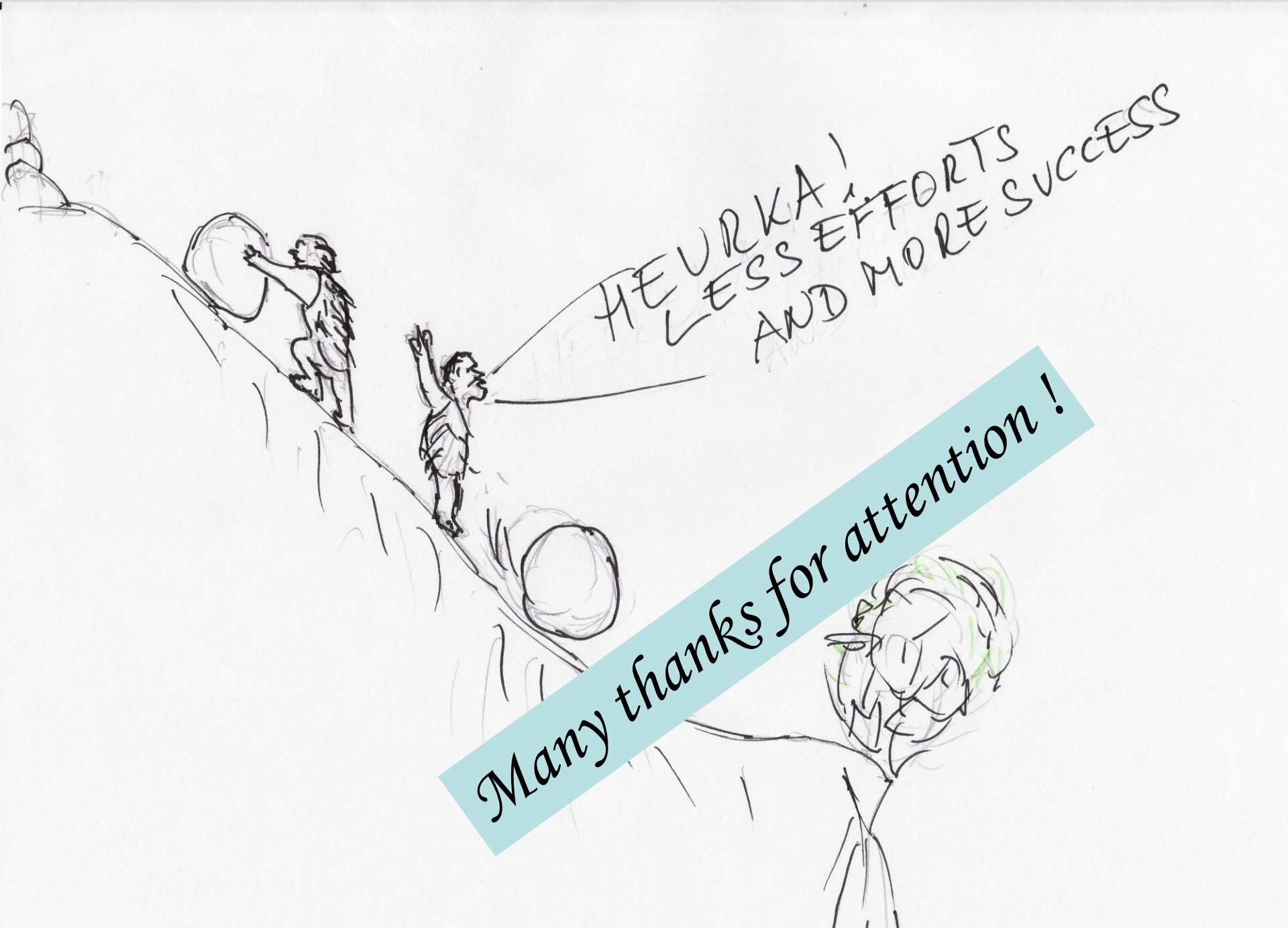
# And the future ?

**Will depend**

- On the awareness, that solutions for the human societies can not be provided by technology
- But, on social efforts to adapt organisational and technological conditions to human mental capacities
- under harmonized consideration of local peculiarities, and commons at larger scales.

# For orientation, a simple preliminary map of virtual spaces of responsibilities






Many thanks for attention !